N O T I C E

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National
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National
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Public Affairs Division
NASA Headquarters
Washington, D.C. 20546

Index

Edwin E. Aldrin, Jr., lunar module pilot photographed during Apollo 11 extravehicular activity by Neil A. Armstrong, commander.

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OF POOR QUALITY

The original seven astronauts: front row, left to right: Schirra, Slayton, Glenn, Carpenter; back row, Shepard, Grissom, Cooper

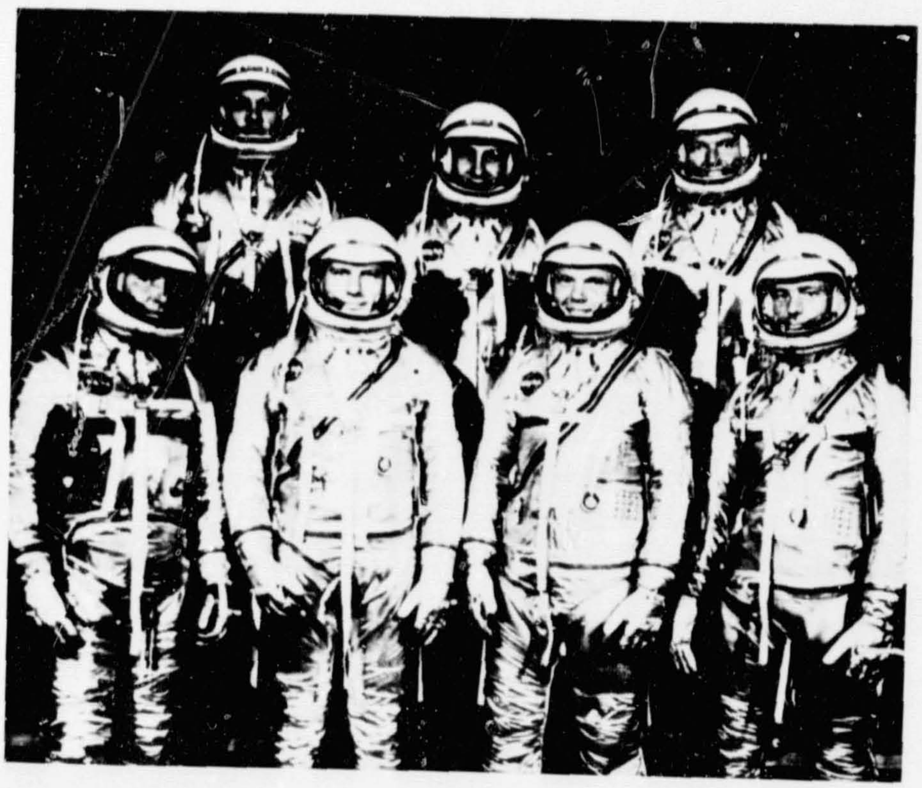
This is NASA

Twenty years ago, on October 1, 1958, the National Aeronautics and Space Administration became an independent civilian agency under the Executive Department of the Federal government. Its predecessor was the National Advisory Committee for Aeronautics, created March 3, 1915, by President Woodrow Wilson. NACA, as it was known before being absorbed by NASA, was the product of far-sighted men who were concerned about the nation's then-primitive state of aviation technology as the nations of Europe were moving ahead with the aircraft as a weapon for World War I. At Kitty Hawk, NC, on December 17, 1903, the Wright Brothers of Dayton, OH, had flown their flimsy—but powered and heavier-than-air—machine to put the U.S. in front in aeronautics. NACA's immediate task was to survey the state of the art and put the U.S. in front again. The Army and Navy stepped up research and development and NACA built its first research center, Langley, at Hampton, VA, delayed by World War I until 1920, as the first facility of the government to coordinate aeronautical research in the civil and military sectors. NACA, along with other concerned government and private agencies, was doing its job impressively. But it, with the rest of the world, was jolted on October 4, 1957, when the Soviet Union successfully orbited Sputnik 1. The U.S. was already engaged in jetrocket research. But it was not until January 31, 1958, that the U.S. successfully placed Explorer 1 in Earth orbit. With a payload of 14 kilograms, Explorer 1 nonetheless revealed, through an experiment aboard, the existence of a dense belt of radiation around the Earth at 965 kilometers altitude—the Van Allen belt.

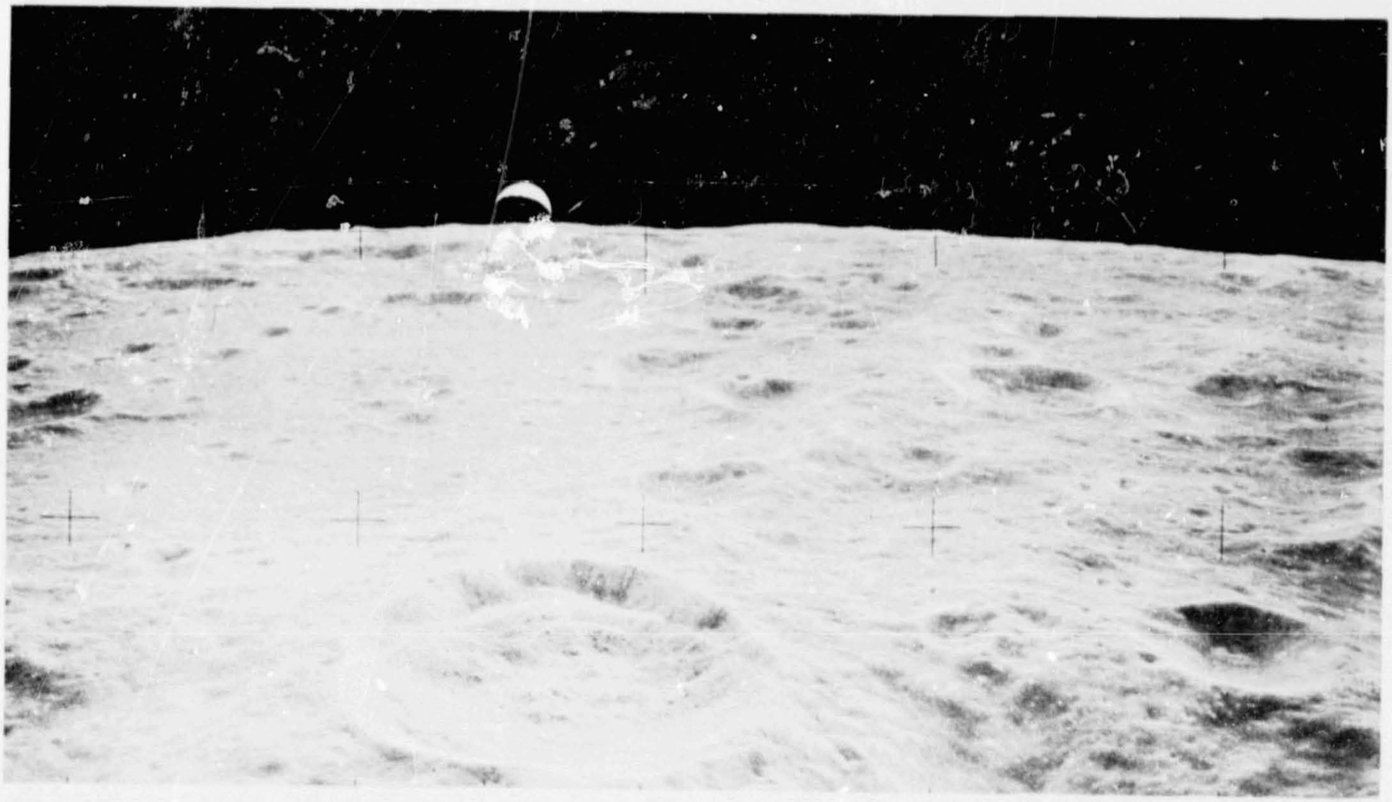
Meanwhile, in those tense months, both consensus and competition had been forming on the political front: consensus that a national augmented space program was essential; competition as to who would run such a program, in what form, with what priorities. The Department of Defense, with its component military services, was an obvious front runner. The Atomic Energy Commission, already working with nuclear warheads and nuclear propulsion, had some congressional support, particularly in the Joint Committee on Atomic Energy. And there was NACA.

NACA had devoted more and more of its facilities, budget, and expertise to missile research in the mid and late 1950's. Under the skillful leadership of James H. Doolittle, Chairman, and Hugh L. Dryden, Director, the strong NACA research team had come up with a solid, long-term, scientifically based proposal for a blend of aeronautic and space research. Its concept for manned spaceflight, for example, envisioned a ballistic-shaped spacecraft with a blunt reentry shape, backed by a world-encircling tracking system, and equipped with dual automatic and manual controls that would enable the astronaut gradually to take over more and more of the flying of his spacecraft. Also, NACA offered reassuring experience of long, close working relationships with the military services in solving their research problems, while at the same time translating the research into civil applications. But NACA's greatest political asset was its peaceful, research-oriented image. President Eisenhower and Senator Johnson and others in Congress were united in wanting above all to avoid projecting cold-war tensions into the new arena of outer space.

By March 1958 the consensus in Washington had jelled. The Administration position—largely credited to James R. Killian, in the new post of President's Special Assistant for Science and Technology—the findings of Senator Johnson's Preparedness Subcommittee, and the NACA proposal converged. America needed a national space program. The military component would of course be under DOD. But a civil component, lodged in a new agency, technologically and scientifically based, would pick up certain of the existing space projects and forge an expanded program of space exploration in close concert with the military. All these concepts fed into draft legislation. On April 2, 1958, the Administration bill for establishing a National Aeronautics and Space Agency was submitted to Congress; both Houses had already established select space committees; debate ensued, a number of refinements were



"It's a beautiful day in the land of Fra Mauro," said Apollo 14 commander Shepard. Beyond the crater-pocked horizon rises Earth, a thin crescent against the backdrop of a velvety sky.



introduced, mostly by (then Senate Majority Leader) Lyndon B. Johnson; and on July 29, 1958, President Eisenhower signed into law P.L. 85-568, the National Aeronautics and Space Act of 1958.

The Act established a broad charter for civilian aeronautical and space research, with unique requirements for dissemination of information; absorbed the existing NACA into the new organization as its nucleus; and empowered broad transfers from other government programs.

In August President Eisenhower had nominated T. Keith Glennan, President of Case Institute of Technology and former Commissioner of the Atomic Energy Commission, to be the first Administrator of the new organization, NASA, and Dryden to be Deputy Administrator. Quickly confirmed by the Senate, they were sworn in on August 19. Glennan reviewed the planning efforts, approved most. Talks with the Advanced Research Projects Agency (ARPA) identified the military space programs that were space-science oriented and obvious transfers to the new agency. A site was chosen—two square kilometers of the Department of Agriculture's research center in Maryland. In March 1961 the Robert H. Goddard Space Flight Center (named for America's rocket pioneer) was dedicated in Greenbelt, MD. NASA was on the move.

Retrospect—20 Years of NASA

Where has NASA taken us? From the thin ribbon of Earth's atmosphere to the edge of the solar system since its inception October 1, 1958. The Moon, Mars, Venus, Jupiter, Saturn being explored. Pulsars, quasars, black holes—all stunning clues to the lifestyle of the Universe. Solar flares, the solar corona, the internal structure of the Sun, all of which have put new light on research to harness energy on Earth. Quieter aircraft engines, the supercritical wing, economies in fuel consumption of aircraft. Vast improvements in worldwide communications, weather prediction, crop inventories, improved knowledge of oceanic ice movements, of fish migrations, of urban development, of broad patterns of geological formations relating to mineral deposits and earthquakes. An expanded industrial and university capacity for high-caliber research and development, high-performance workmanship: these are some of the returns from the nation's investment in a civilian aeronautics and space program undertaken two decades ago.

Beyond these returns, which ones are the most noteworthy of the less tangible but nonetheless real returns on the taxpayers' dollars? The international space program, with more than 80 nations involved in mutually beneficial aerospace projects? The joint Soviet-American Apollo-Soyuz flight which, for the time at least, straightened the tortuous path of detente by its irrefutable need for, and achievement of, significant cooperation? The longer-term import of new insights from space sciences on origins of spacecraft Earth, its mineral and energy resources, the fragility of its thin atmospheric envelope?

And beyond the present and near future, what of the historical lessons?

NASA Administrator Robert A. Frosch

Where else in the twentieth-century history of our nation is more clearly encapsulated our dangerous national trait of international roulette—of a deep-seated complacency that can be penetrated only by extreme challenge: World War I and the too-late founding of NACA; World War II and the belated threefold expansion of NACA; the Cold War and scrambling from behind to NASA and Apollo?

The course of history tells us that new truths, once exposed, defy turning back the clock. The door to aeronautics and space has been opened. It can no more be slammed shut than could the door opened by Gutenberg's printing press or by gunpowder; by Galileo's telescope or by the steam engine; by Pasteur's micro-organism discoveries or by the unleashing of nuclear energy. History impartially muses: who will have the vision and steadfastness of purpose to make the most of this newly opened door?

Finally, what of long-term qustions? Will peaceful space competition prove to be a constructive alternative to war on Earth? Will space settlement be the eventual answer to overpopulation and depletion of the fragile planet Earth? Are there super-civilizations in the outer reaches of the Universe who can teach earthlings how to resolve their conflicts?

In all humility, only one finding is certain: our first faltering steps into space have reaped incalculable, unforeseen rewards. Future possibilities are as limitless as man's enterprise chooses to venture.

Federal Research and Development, FY 1980

Obligations for the conduct of all R&D, including basic research, are expected to total \$30.6 billion in 1980, an increase of \$1.2 billion or 4.2% over 1979. Outlays for all R&D are estimated to be about \$29.7 billion, about \$2.1 billion or 7.6% over 1979. Obligations for the conduct of R&D in the National Aeronautics and Space Administration are estimated to total \$4.5 billion in 1980, \$148 million over 1979. There will also be a supplemental outlay of \$163.2 million to handle the increased cost of the Shuttle.

Where is NASA in 1979?

As we approach the 1980's NASA finds itself an established, mature government agency contributing importantly and increasingly to the national welfare.

The dramatic and spectacularly successful manned space flights to the Moon and near space are history—proud history indeed for our country and mankind—and our agency has settled down to a steady pursuit of challenging but realistic goals in the atmosphere and in space. Where we were at one time our own primary customer, we have become an imaginative, useful agency providing unique and needed services to other government organizations, to industry, to the scientific community, to the public, to other nations, and in fact to all humanity.

But this transition does not make our work any less exciting. In the tradition we were born to, we continue to expand the frontiers of technology and human knowledge for the benefit of everyone.

In aeronautics, progress in aerodynamics, composite materials, advanced engine technology and control systems holds great promise. These developments may well lead to 50% fuel savings for airliners, to vertical and short take-off and landing aircraft with efficient, clean, quiet engines, and to environmentally acceptable supersonic air travel at reasonable cost.

Greatly improved Earth observation systems and communications satellites are providing a wide range of direct benefits, from more economical and efficient worldwide communications to more accurate weather warning and forecasting, and natural resources discovery and inventory.

Our planetary probes are searching out the secrets of the solar system in perhaps the greatest scientific adventure of all time. Simultaneously, space-based observations platforms are sweeping the universe with their sensors, providing unprecedented new data which bears directly on the creation and evolution of matter and energy and the place of Earth and humanity in the cosmos.

And the future is as promising as the present; with new aeronautical research facilities becoming available to help us keep aircraft "made in America" dominant on the airways of the world; with the Space Shuttle approaching the operational status which will give us frequent, easy and economical access to space for all purposes; with the Space Telescope permitting us to see back almost to the beginning of time; with our planetary probes contributing new information from afar; with the Landsat satellite series expanding our knowledge of our own planet and its resources; and with the technological advances derived from research on these programs being systematically transferred to every sector of our society.

Beyond our new horizons in aeronautics and in space lies a better life for the people of this planet.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION U.S.A.

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Deputy Administrator
Dr Alan M Lovelace

Associate Deputy Administrator
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(Vacant)

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Dr Anthony J Calio

Associate Administrator for Space Transportation Systems
John F Yardley

Associate Administrator for Space Tracking & Data Systems
Dr William C Schneider

Ames Research Center
Moffett Field Calif
C A Syvertson

Dryden Flight Research Center
Edwards Calif
Isaac T Gillam

Goddard Space Flight Center
Greenbelt Md
(Vacant)

George C Marshall Space Flight Center
Huntsville Ala
Dr William R Lucas

Jet Propulsion Laboratory
(Contractor Operated)
Pasadena Calif
Dr Bruce C Murray

John F Kennedy Space Center
Kennedy Space Center Fla
(Vacant)

Langley Research Center
Hampton Va
Donald P Hearth

Lewis Research Center
Cleveland Ohio
Dr John F McCarthy Jr

Lyndon B Johnson Space Center
Houston Texas
Dr Christopher C Kraft Jr

Wallops Flight Center
Wallops Island Va
Robert L Krieger

National Space Technology Laboratories
NSTL Station Miss
J Jerry Hlass

Note: Letters after titles are mail codes.

NASA Headquarters, Washington, D.C.

Planning, coordination, and control of NASA programs are vested in Headquarters. Directors of NASA's Field Centers and other installations are responsible for execution of NASA's programs, largely through contracts with research, development, and manufacturing enterprises. A broad range of research and development activities are conducted in NASA's installations by government-employed scientists, engineers, and technicians to evaluate new concepts and phenomena and to maintain the competence required to manage contracts with private enterprises.

Planning, direction, and management of NASA's research and development programs are the responsibility of the program offices which report to, and receive overall guidance and direction from, the Associate Administrator. The overall planning and direction of operations at the 10 Field Centers and the National Space Technology Laboratories, and management agency wide institutional resources are the responsibility of the Associate Administrator for Center Operations.

A brief description of the responsibilities of the program offices follows:

Aeronautics and Space Technology

The Office of Aeronautics and Space Technology is responsible for the aeronautical and space research and technology programs. The aeronautics program develops the technology needed to assure safer, more efficient, economical and environmentally acceptable air transportation systems which are responsive to national needs. The space research and technology program provides a technology base to support current and future space activities. This office is also responsible for coordinating the agency's total program of supporting research and technology related to carrying out specific flight missions to insure an integrated and balanced agency research program. This office also is responsible for coordinating NASA's support of other federal agencies in energy research and development.

Applications of Space Research

The Office of Space and Terrestrial Applications is responsible for research and development activities leading to programs providing beneficial applications of space systems, and space-related or derived systems and monitoring, earth dynamics monitoring and forecasting, ocean condition monitoring and forecasting, environmental quality monitoring, weather and climate observation and forecasting, communications, and transfer of technology to the non-government sector.

Space Transportation

The Office of Space Transportation Systems is responsible for the research, development, and operations of space flight programs including the Space Shuttle, the essential element of the Space Transportation System that will be used to conduct the space operations of the 1980's. The Space Transportation System consists of the Shuttle, a reusable vehicle; and Spacelab, and experiments payload carrier being developed by the European Space Agency (ESA). The Space Transportation Systems Office also has program responsibility for expendable launch vehicles.

Space Science

The Office of Space Sciences is responsible for scientific research and development activities using a variety of flight systems and ground-based observations to increase man's knowledge of the universe. The Earth, Sun, Moon, the planets, interplanetary space, other stars and galaxies, and the interaction among these bodies and systems are all objects of these investigations. The Life Sciences program also is under the direction of the Office of Space Sciences.

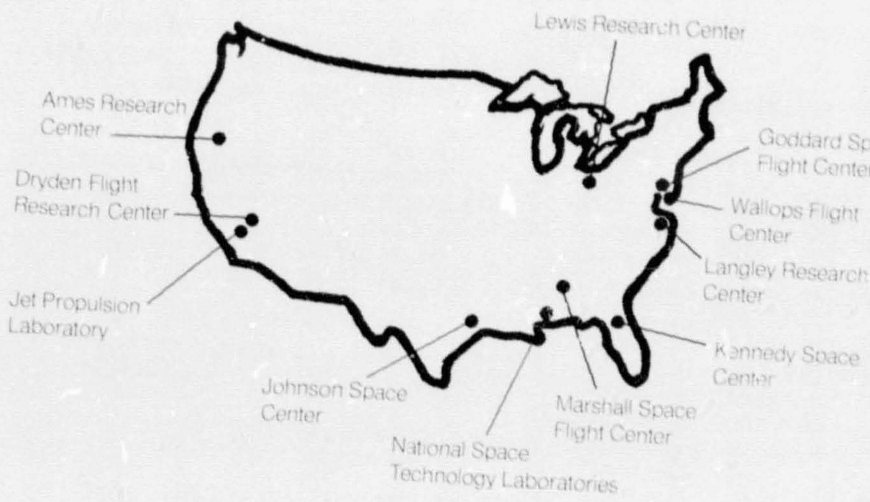
Tracking and Data Acquisition

The Office of Space and Data Systems is responsible for the development, implementation, and operation of tracking, data acquisition, command, communications, data processing facilities, and systems and services required to support NASA flight missions. This office also provides centralized planning and systems management for the administrative communications of NASA installations.

Field Installations

A brief description of the program responsibilities of NASA's ten principal field centers and the National Space Technology Laboratories follows:

Ames Research Center, Moffett Field, California 94035:
Space environmental physics; simulation techniques; gas dynamics at extreme speeds; configuration, stability, structures, and guidance and control of aeronautical and space vehicles; biomedical and biophysical research.



Hugh L. Dryden Flight Research Center, Edwards, California 93523:
General aviation and extremely high-performance aircraft and spacecraft; flight operations and flight systems; structural characteristics of aeronautical and space vehicles.

Goddard Space Flight Center, Greenbelt, Maryland 20771:
Scientific research in space with unmanned satellites; research and development of meteorological and communications satellites; tracking and data acquisition operations.

Jet Propulsion Laboratory, Pasadena, California 91103:
(Operated under contract by the California Institute of Technology): Deep space, lunar and interplanetary spacecraft; operation of related tracking and data acquisition systems.

Lyndon B. Johnson Space Center, Houston, Texas 77058:
Research and development of manned spacecraft system; development of astronaut and crew life support systems; development and intergration of experiments for space flight activities; application of space technology, and supporting scientific, engineering, and medical research.

John F. Kennedy Space Center, Florida 32899:
Provision of supporting activities for the major launchings; preparation and integration of space vehicles; collaboration with elements of the Department of Defense as the Eastern Test Range and Corps of Engineers to avoid unnecessary duplication of launch facilities, services, and capabilities.

Langley Research Center, Hampton, Virginia 23665:
Aeronautical and space structures and materials; advanced concepts and technology for future aircraft; aerodynamics of re-entry vehicles; space environmental physics; improved supersonic flight capabilities.

Lewis Research Center, Cleveland, Ohio 44135:
Power plants and propulsion; high energy propellants; electric propulsion; aircraft engine noise reduction; engine pollution reduction; data bank of research information in aerospace safety.

George C. Marshall Space Flight Center, Alabama 35812:
Research and development of launch vehicles and systems to launch vehicles and systems to launch manned and unmanned spacecraft; development and integration of payloads and experiments for assigned space flight activities; application of space technology and supporting scientific and engineering research.

National Space Technology Laboratories, Bay St. Louis, Mississippi 39520:
Static test firing of large space and launch vehicle engines; also houses certain environmental research and earth resources activities of NASA and other governmental agencies, with emphasis on the use of space technology and associated managerial and technical disciplines.

Wallops Flight Center, Wallops Island, Virginia 23337:
Launch facilities and services for other NASA installations which conduct suborbital, orbital, and space probe experiments with vehicles ranging from small rockets to the Scout four-stage solid fuel rocket. Development of techniques for collection and processing of experimental data.

Visitor Information—NASA Centers

Ames Research Center

Tour Information:
Public Affairs Office, Ames Research Center, Moffett Field, CA. 94035, Area Code 415, 965-5091, extension 2671.

Tours:
Only for previously scheduled tour groups of an educational or professional category. Tours are prearranged; 8 a.m. to 4:30 p.m., Monday through Friday. Tours are guided.

Mode of Travel:
Walking, auto or bus, depending on what is furnished by tour group.

Advance Notice:
One month, varies.

Points of Interest:
Wind tunnels, simulators, life sciences and space sciences labs, aircraft, machine shops, and others involving the crafts.

Other Pertinent Information:
Students should be third-grade or above. Cameras are permitted.

Hugh L. Dryden Flight Research Center

Tour Information:
Public Affairs Office, Dryden Flight Research Center, P.O. Box 273, Edwards, CA 93523, Area Code 805, 258-3311, extension 221.

Tours:
7:30 a.m. to 4 p.m., Monday through Friday. Tours are guided.

Mode of Travel:
On foot.

Advance Notice:
Advance request.

Points of Interest:
Restricted to the main hangar.

Other Pertinent Information:
Cameras are permitted.

Goddard Space Flight Center

Tour Information:
Write to Public Affairs Office, Director, GSFC, Greenbelt, MD 20771.
Other Information:
Special Programs Office, Area Code 301 - 344-8101.

Tours:
Begin at 10 a.m. and/or 1 p.m., Monday through Friday. Occasional Saturday tours at 10 a.m. Tours preceded by 20-minute orientation and short films. Tours are guided.

Mode of Travel:
Normally buses provided by visiting groups used for transportation between buildings.

Advance Notice:
Tours scheduled on advanced arrangement basis.

Points of Interest:
Tracking and data systems facilities (control centers, communications, computers), test and evaluation area (simulation equipment), satellite exhibit room (full-scale satellites and demonstration devices).

Other Pertinent Information:
Occasional evening tours scheduled for special groups, e.g.: professional societies. GSFC does not have a public tour program. Goddard's program is for special-interest groups or educational groups of sixth-grade level and above.

Jet Propulsion Laboratory

Tour Information:
Public Affairs Office, Public Educational Services, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91103, Area Code 213, 354-5011 or 354-2337.

Tours:
Available for educational, professional, and service organizations; 8 a.m. to 4:30 p.m., Monday through Friday. The contents of the tours vary with the interest groups. Tours are guided.

Mode of Travel:
Bus provided by group or walking.

Advance Notice:
One month requested. All tours are prearranged.

Points of Interest:
Spacecraft exhibit center; features hardware, exhibits, films, spacecraft assembly facilities, spacecraft operations facilities, environmental labs, navigational and guidance labs, celestarium, soil lab, anechoic chamber.

Other Pertinent Information:
Tours last 2 to 2 1/2 hours and are limited to seventh-grade students and above. Cameras are permitted.

Lyndon B. Johnson Space Center

Tour Information:
Public Services Branch, Johnson Space Center, Houston, TX 77058, Area Code 713, 483-4241.

Tours:
Reserved guided tours Monday through Friday of Mission Control Center, other operating facilities. Self-guided tours seven days a week of exhibit hall, astrotraining facilities, and other facilities. Open daily except Christmas Day, 9 a.m. to 4 p.m.

Mode of Travel:
Public may walk or drive through.

Advance Notice:
Reservations required for guided tours or special group tours.

Points of Interest:
Astronaut training facilities, Mission Control Center, exhibit hall, film schedule every 40 minutes.

Other Pertinent Information:
Cafeteria open to public. Souvenir stand.

John F. Kennedy Space Center

Tour Information:
NASA Tours, Post Office Box 21222, Kennedy Space Center, FL 32815, Area Code 305, 269-3000.

Tours:
Guided bus tours depart regularly from 8 a.m. until two hours before dark daily except Christmas day. Cameras encouraged. Tour covers 50 miles, lasts approximately two hours.

Mode of Travel:
Air conditioned buses are provided by TWA. Charter buses provided by tour groups are welcome. Fares are: Adults - $2.50, Youths (12-18) - $1.25, Children (3 to 11 with an adult)-$.50. Student groups of 20 or more: through junior high $.50, senior high and other student groups $1.00. Charter and convention groups of 25 or more in their buses receive 25% fare reduction.

Advance Notice:
24 hours for charter buses requested.

Points of Interest:
Vehicle Assembly Building, Mission Control Center, blockhouse, mobile launches and service structure, transporters, launch pads and launch facilities, Air Force Museum. Visitor Information Center (VIC). Exhibits, films lectures, and souvenirs.

Other Pertinent Information:
The public bus tours of KSC and Cape Kennedy are operated by Trans World Airlines, contractor to NASA. Private vehicles are admitted free to drive through only on Sunday from 9 a.m. to 3 p.m. on a prescribed route.

Langley Research Center

Tour Information:
Public Affairs Office, Langley Research Center, Hampton, VA 23361, Area Code 804, 827-3966.

Tours:
9 a.m. to 4 p.m., Tuesday through Saturday, noon to 4 p.m., Sunday. Monday and evening by appointment. Tours are self-guided except for groups by appointment.

Mode of Travel:
Cars or buses provided by visiting groups. During the period Memorial Day to Labor Day also by special bus provided through City of Hampton Tour.

Advance Notice:
None, except for Mondays or special evening programs.

Points of Interest:
Visitor Center opened June 8, 1971. Aeronautical and space exhibits as well as selected films and educational programs.

Other Pertinent Information:
Laboratory tours are limited to special groups determined by visit objective and educational and professional background of guests.

Lewis Research Center

Tour Information:
Educational Services Office, Lewis Research Center, Cleveland, OH 44135, Area Code 216, 433-4000, extension 731.

Tours:
9 a.m. to 4 p.m. Tuesday - Friday. Saturday 10 a.m. to 3 p.m. Sunday and Monday - closed.

Mode of Travel:
Cars or buses provided by visiting groups.

Points of Interest:
Visitor Information Center; aeronautics and space exhibits, films, presentations, and special resource facilities for educators only (prior arrangements required); materials research lab; 10 x 10 foot supersonic wind tunnel; propulsion science lab; energy conversion lab; various shop facilities; and the zero-gravity facility.

Marshall Space Flight Center

Tour Information:
Public Affairs Office, Marshall Space Flight Center, AL 35812. Area Code 205, 453-0038 or 453-0040.

Tours:
Bus tours daily except Christmas Day from the NASA Visitor Information Center located in the lobby of the Alabama Space and Rocket Center, Huntsville, AL (guided). Nominal fee charged. Group rates available and special rates for student groups.

Mode of Travel:
Tour buses make regular runs. Guide provided on commercial or school group buses.

Advance Notice:
Contact Alabama Space and Rocket Center two weeks in advance for group tour. No advance notice required for individuals or families.

Points of Interest:
From Alabama Space and Rocket Center, 1-hour 45-minute tour visits test areas and inside laboratories. Tours visit inside Skylab crew quarters full-size high-fidelity mockup, the Neutral Buoyancy Simulator, full-size Space Shuttle mockup area, and solar heating and cooling research area.

Marshall Visitor Information Center has free access and contains several exhibits including a lunar sample, a crystal grown in space aboard Skylab, and the Wernher von Braun room. From the visitor center area, fees charged for access to Alabama Space and Rocket Center and for bus tours.

Other Pertinent Information:
Special purpose tours of MSFC available as determined by scientific and professional background of guests.

National Space Technology Laboratories

Tour Information:
National Space Technology Laboratories, Public Affairs Office, Bay St. Louis, MS 39520. Area Code 601, 688-3341.

Tours:
10 a.m. to 2 p.m., Monday through Saturday; 1:30 and 3 p.m. Sunday. Central Control Building open to public 8 a.m. to 4:30 p.m. (self-guided). Tours are guided.

Mode of Travel:
Buses.

Advance Notice:
One week in advance for special tours.

Points of Interest:
Saturn V test complex, booster storage area, flight and test maintenance buildings. Navigational lock system. Canal and barge system. Central control building contains exhibits, films, and observation tower.

Wallops Flight Center

Tour Information:
Public Affairs Office, Wallops Flight Center, Wallops Island, VA 23337, Area Code 804, 824-3411, Extension 579 or 584.

Tours:
Between 9 a.m. and 4 p.m., Monday through Friday by reservation only. During school term for student or organized groups and during the summer for family groups. Tours are guided.

Mode of Travel:
Bus or auto, depending on what is furnished by tour group.

Advance Notice:
Two weeks prior notice.

Points of Interest:
Range Control Center, telemetry station, radar tracking site, rocket assembly and launch facilities, blockhouses and aeronautical programs, exhibit area at main base.

Other Pertinent Information:
Tours are tailored to some extent to size, age level, and interest of group. Shorter tours provided for younger children.

Western Test Range

Tour Information:
Western Test Range, Operations Division, NASA Public Affairs Office, Post Office Box 425, Lompoc, CA, Area Code 805, 865-3015.

Tours:
Only for previously arranged groups. Security checkups are standard as this is also a SAC base. Tours are guided.

Mode of Travel:
Auto or buses provided by NASA.

Advance Notice:
Several weeks.

Points of Interest:
NASA facilities, launch complexes, support facilities, tracking operations, Scout complex blockhouse.

Skylab Reentry

NASA's Skylab, launched from Kennedy Space Center, FL, May 14, 1973 and occupied for a total of 171 days, 13 hours and 14 minutes by three three-man crews, reentered Earth's atmosphere July 11, 1979. The orbiting workshop disintegrated at 12:37 p.m. EDT during its 34,981st revolution of Earth, scattering its debris over the Indian Ocean and Australia's sparsely-populated western desert. No damage to persons or property was reported.

Office of the White House Press Secretary
October 11, 1978

The White House
Fact Sheet
U.S. Civil Space Policy

The President announced today a space policy that will set the direction of U.S. efforts in space over the next decade. The policy is the result of a four-month interagency review requested by the President in June 1978. American civil space policy will be centered around three tenets:

First: Our space policy will reflect a balanced strategy of applications, science and technology development containing essential key elements that will:

—Emphasize space applications that will bring important benefits to our understanding of earth resources, climate, weather, pollution and agriculture, and provide for the private sector to take an increasing responsibility in remote sensing and other applications.

—Emphasize space science and exploration in a manner that retains the challenge and excitement and permits the nation to retain the vitality of its space technology base, yet provides short-term flexibility to impose fiscal constraints when conditions warrant.

—Take advantage of the flexibility of the space shuttle to reduce the cost of operating in space over the next two decades to meet national needs.

—Increase benefits for resources expended through better integration and technology transfer among the national space programs and through more joint projects when appropriate, thereby increasing the return on the $100 billion investment in space to the benefit of the American people.

—Assure American scientific and technological leadership in space for the security and welfare of the nation and continue R&D necessary to provide the basis for later programmatic decisions.

—Demonstrate advanced technological capabilities in open and imaginative ways having benefit for developing as well as developed countries.

—Foster space cooperation with nations by conducting joint programs.

—Confirm our support of the continued development of a legal regime for space that will assure its safe and peaceful use for the benefit of mankind.

Second: More and more, space is becoming a place to work—an extension of our environment. In the future, activities will be pursued in space when it appears that national objectives can most efficiently be met through space activities.

Third: It is neither feasible nor necessary at this time to commit the United States to a high-challenge space engineering initiative comparable to Apollo. As the resources and manpower requirements for shuttle development phase down, we will have the flexibility to give greater attention to new space applications and exploration, continue programs at present levels or contract them. To meet the objectives specified above, an adequate Federal budget commitment will be made.

Space Applications

As a part of his overall review and in accordance with his desire to increase emphasis on uses of space for a wide variety of practical and economic benefits the President made the following decisions:

Remote Sensing Systems. Since 1972 the United States has conducted experimental civil remote sensing through LANDSAT satellites. There are many successful applications and users, including Federal departments, other nations, a number of states, and a growing number of commercial organizations. The United States will

NASA Administrators, Deputy and Acting Administrators

Administrators	
Dr. T. Keith Glennan	August 19, 1958 - Jan. 20, 1961
Mr. James E. Webb	February 14, 1961 - Oct. 7, 1968
*Dr. Thomas O. Paine**	March 21, 1969 - Sept. 15, 1970
Dr. James C. Fletcher	April 27, 1971 - May 1, 1977
Dr. Robert A. Frosch	June 21, 1977 - Present
Deputy Administrators	
*Dr. Hugh L. Dryden***	August 19, 1958 - Dec. 2, 1965
Dr. Robert C. Seamans, Jr.	December 21, 1965 - Jan. 5, 1968
Dr. Thomas O. Paine	March 25, 1968 - March 20, 1969
Mr. George M. Low	December 3, 1969 - June 5, 1976
Dr. Alan M. Lovelace	July 2, 1976 - Present
Acting Administrators	
Dr. Hugh L. Dryden	January 21, 1961 - Feb. 13, 1961
Dr. Thomas O. Paine	October 8, 1968 - March 20, 1969
Mr. George M. Low	Sept. 16, 1970 - April 26, 1971
Dr. Alan M. Lovelace	May 2, 1977 - June 20, 1977

* Service as Administrator or Deputy Administrator begins on the day of swearing in. In Dr. Paine's case, although he was sworn in on April 3, 1969, his service as Administrator began on March 21, 1969 (date of app't), because he had already taken his oath to the government when he became Deputy Administrator.

**Dr. Dryden's resignation date is date of death.

continue to provide data from the developmental LANDSAT program for all classes of users. Operational uses of data from the experimental system will continue to be made by public, private, and international users. Specific details and configurations of the LANDSAT system and its management and organizational factors will evolve over the next several years to arrive at the appropriate technology mix, test organizational arrangements, and develop the potential to involve the private sector.

Integrated Remote Sensing System. A comprehensive plan covering expected technical, programmatic, private sector, and institutional arrangements for remote sensing will be explored. NASA will chair an interagency task force to examine options for integrating current and future systems into an integrated national system. Emphasis will be placed on defining and meeting user requirements. This task force will complete its review prior to the FY 1981 budget cycle.

Weather Satellites. Separate operational requirements for meteorological data over the past two decades have led to separate Defense and Commerce's National Oceanic and Atmospheric Administration (NOAA) weather satellites. The Defense community, NASA, and NOAA will conduct a review of meteorological satellite programs to determine the degree to which these programs might be consolidated in the 1980s and the extent to which separate programs supporting specialized defense needs should be maintained. The possibility of integrated systems for ocean observations from space will also be examined.

The Private Sector. Along with other appropriate agencies, NASA and Commerce will prepare a plan of action on how to encourage private investment and direct participation in civil remote sensing systems. NASA and Commerce will be the contacts for the private sector on this matter and will analyze proposals received before submitting to the Policy Review Committee (Space) for consideration and action.

Communications Satellite R&D. United States leadership in communications satellite systems will be supported by NASA. Selected technological opportunities to provide better frequency and orbit utilization and other longer-term opportunities will be pursued.

Communications Satellite Services. Some areas of communications services—such as educational and health services and basic communications services for remote areas—involve low-volume and intermittent use and have evidenced little interest from commercial satellite operators. The Department of Commerce's National Telecommunications and Information Administration (NTIA) will assist in market aggregation, technology transfer, and possible development of domestic and international public satellite services. This direction is intended to stimulate the aggregation of the public service market drawing on the technology that is already in existence. The Agency for International Development and Interior will work with NTIA in translating domestic experience in public service programs into potential programs for lesser-developed countries and the remote territories.

Future Applications and Economic Activity. It is too early to make a commitment to the development of a satellite solar power station or space manufacturing facility due to the uncertainty of the technology and economic cost-benefits and environmental concerns. There are, however, very useful intermediate steps that will allow the development and testing of key technologies and experience in space industrial operations to be gained. The United States will pursue an evolutionary program that is directed toward assessing new options which will be reviewed periodically by the Policy Review Committee (Space). The evolutionary program will stress science and basic technology—integrated with a complementary ground R&D program—and will continue to evaluate the relative costs and benefits of proposed activities.

Space Science and Exploration

The President reviewed the space science and planetary exploration program and determined that the United States' priorities at any given time will depend on the promise of the science, the availability of the particular technology, and the budgetary situation. The United States will maintain a position of leadership in space science and planetary exploration and will:

—Continue a vigorous program of planetary exploration to understand the origin and evolution of the solar system. The goal in the years ahead is to continue the reconnaissance of the outer planets and to conduct more detailed exploration of Saturn, its moons, and its rings; to continue comparative studies of the neighboring planets, Venus and Mars; and to conduct reconnaissance of comets and asteroids.

—Utilize the space telescope and free-flying satellites to usher in a new era of astronomy, as we explore interstellar molecules, quasars, pulsars, and black holes to expand our understanding of the universe.

—Develop a better understanding of the sun and its interaction with the terrestrial environment through space systems—such as the Solar Maximum Mission and the Solar Polar Mission—that will journey towards the sun and earth-orbiting satellites that will measure the variation in solar output and determine the resultant response of the earth's atmosphere.

—Utilize the space shuttle and spacelab, alone and in cooperation with other nations, to conduct basic research that complements earth-based life science investigations and human physiology research.

Our policy in international space cooperation will include two basic elements: (1) to pursue the best science available regardless of national origin and expand our international planning and coordinating effort; and (2) to seek cooperative support for experiments-spacecraft which have been chosen on sound scientific criteria.

Increased Benefit for Resources Expended

As a result of the President's review, decisions were made that will increase the benefit to the United States for resources expended.

"Columbia," the first Shuttle Orbiter destined to fly in space arrives at the Kennedy Space Center launch site atop 747 carrier aircraft.

Strategy to Utilize the Shuttle. The Administration will make incremental improvements in the shuttle transportation system as they become necessary. Decisions on extending the shuttle's stay time in orbit and future upper stage capabilities (e.g., the reusable space tug and orbital transfer vehicle) will be examined in the context of our emerging space policy goals. An interagency task force will make recommendations on what future capabilities are needed. This task force will submit the findings to the Policy Review Committee (Space) prior to the FY 1981 budget cycle.

Technology Sharing. The Policy Review Committee (Space) will take steps to enhance technology transfer between the space sectors. The objective will be to maximize efficient utilization of the sectors while maintaining necessary security and current management relationships.

Background

Early in his Administration, the President directed a National Security Council review of space policy. The emphasis was on coherent space principles and national space policy and did not deal in detail with the long-term objectives of our defense, commercial, and civil programs. The review, completed in May 1978, resulted in a Presidential Directive that set the basic framework for our civil space policy completed last week. The President's May 1978 directive established a Policy Review Committee (Space) to provide a forum for all Federal agencies in which to advise on proposed changes to national space policy and to provide for rapid referral of issues to the President for decision. This Committee is chaired by the Director of the Office of Science and Technology Policy, Frank Press. In June 1978 the President directed the Policy Review Committee (Space) to assess the future needs of the nation's civil space program, and their report formed the basis for the policy decisions outlined here. The following agencies and departments participated: The National Aeronautics and Space Administration, Commerce, Interior, Agriculture, Energy, State, National Science Foundation, Agency for International Development, Defense, Director of Central Intelligence, Joint Chiefs of Staff, and Arms Control and Disarmament Agency, as well as the Domestic Policy Staff, the National Security Council Staff, and the Office of Management and Budget.

NASA Funding, Personnel Statistics

NASA Budget Plan — Millions of Dollars	FY 1979	FY 1980
Research and Development	3477	3602
Space Transportation Systems	2010a/	1904
Space Science	505	602
Space and Terrestrial Applications	284	344
Aeronautical Research and Technology	264	300
Space Research and Technology	112	119
Space Tracking and Data Systems	302	333
Construction of Facilities	147	158
Research and Program Management	942b/	965
Total Budget Plan	4566	4725
Total Outlays	4404	4595

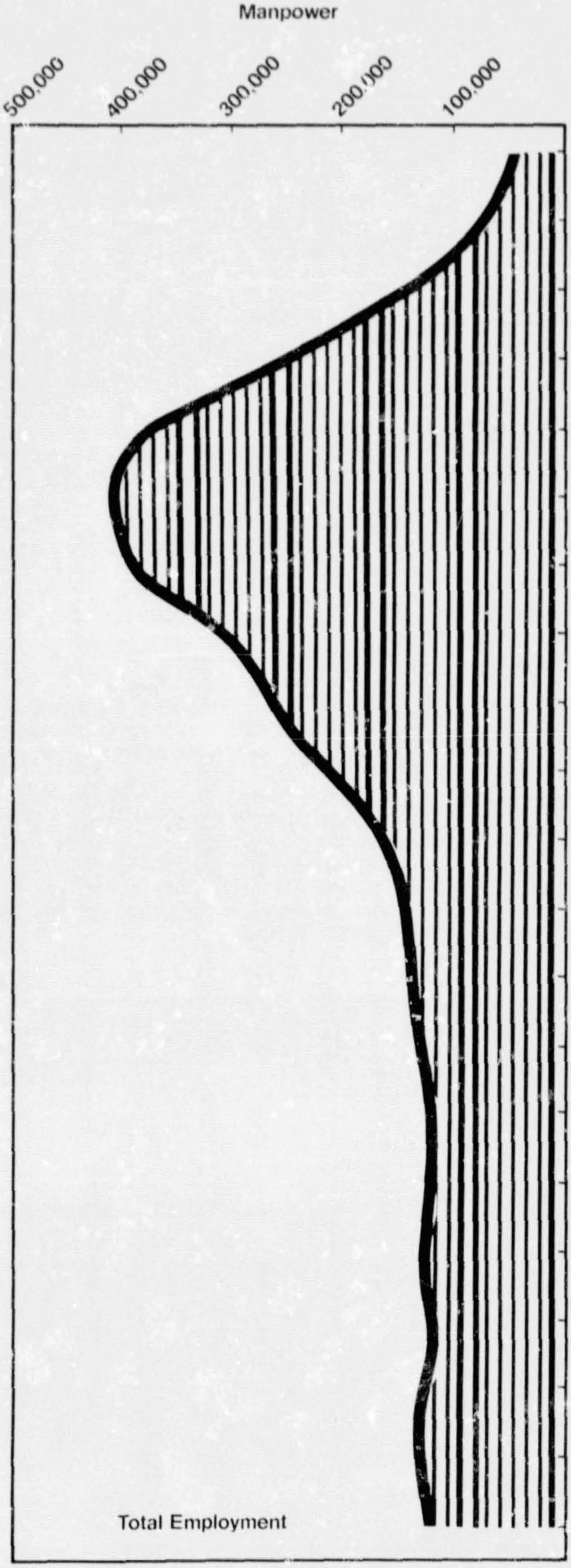
a/ Includes Proposed Supplemental of $185,000,000 for the Space Shuttle
b/ Includes Proposed Supplemental of $30,969,000 for 1979 Pay Increase

Estimated Distribution of Total Budget Plan

Millions of Dollars	FY 1979	FY 1980
Johnson Space Center	1,297	1,258
Kennedy Space Center	362	355
Marshall Space Flight Center	917	945
National Space Technology Laboratories	25	20
Goddard Space Flight Center	641	684
Jet Propulsion Laboratory	255	320
Wallops Flight Center	32	37
Ames Research Center	236	248
Dryden Flight Research Center	35	41
Langley Research Center	286	305
Lewis Research Center	248	266
NASA Headquarters	220	230
Various Locations	12	16
Total	4,566	4,725

Total Number of Permanent Positions

Installation — End of Year	FY 1978	FY 1979	FY 1980
Johnson Space Center	3,532	3,509	3,445
Kennedy Space Center	2,179	2,193	2,187
Marshall Space Flight Center	3,760	3,636	3,561
National Space Technology Laboratories	102	104	103
Goddard Space Flight Center	3,575	3,468	3,440
Wallops Flight Center	407	398	395
Ames Research Center	1,669	1,666	1,653
Dryden Flight Research Center	490	480	461
Langley Research Center	3,071	3,015	2,990
Lewis Research Center	2,921	2,858	2,835
NASA Headquarters	1,531	1,504	1,493
Total	23,237	22,831	22,563



	Total Employment	Contractor Employment	NASA Employees
June 1960	46,786	36,500	10,286
June 1961	74,577	57,500	17,077
June 1962	137,656	115,500	22,156
June 1963	246,304	218,400	27,904
June 1964	379,084	347,100	31,984
June 1965	409,900	376,700	33,200
June 1966	393,924	360,000	33,924
June 1967	306,926	273,200	33,726
June 1968	267,871	235,400	32,471
June 1969	218,345	186,600	31,745
June 1970	167,803	136,580	31,223
June 1971	149,609	121,130	29,479
June 1972	144,968	117,540	27,428
June 1973	134,055	108,100	25,955
June 1974	125,054	100,200	24,854
June 1975	127,733	103,400	24,333
June 1976	132,039	108,000	24,039
Sept. 1977	124,069	100,500	23,569
Sept. 1978	126,037	102,800	23,237
Sept. 1979	127,537	104,300	23,237
Sept. 1980	124,363	101,800	22,563

Space Shuttle astronauts in training.

History of the Apollo Program

Initial planning for a launch vehicle with the heavy payload capability necessary for a manned lunar mission began in April 1957. In August 1958, studies concluded that a clustered booster generating a total of 1.5 million pounds thrust was feasible, and the research and development effort was started to build the booster. Rocketdyne, a division of North American Rockwell Corporation, developed the 200,000-pound-thrust version of the H-1 engine from the previously used Thor and Jupiter H-1 engine by updating the engine and by increasing its thrust. Concurrently, from more advanced studies, the 1.5 million-pound-thrust F-1 engine was conceived for even larger boosters. In October 1958, the Army started the development of a high-performance booster for advanced space missions. Tentatively called Juno V and finally designated Saturn, the booster was turned over to NASA in late 1959.

NASA proposed a manned flight program designated Project Apollo in July 1960. Its goals at that time were earth-orbital and circumlunar flights of a three-man spacecraft. During 1960, McDonnell Douglas Corporation was selected to build the Saturn I second stage (S-IV), and Rocketdyne was chosen to develop the hydrogen-fueled J-2 engine for future upper stages of the Saturn vehicles.

This was the combined proposal presented to the Vice President and approved and transmitted by him to the President. It was the best new initiative the President had seen. So it was that on May 25, 1961, the President stood before a joint session of Congress and proposed a historic national goal:

"Now is the time to take longer strides—time for a great new American enterprise—time for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth. . . .

"I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish."

Astronaut Facts

Of 108 pilots, scientists and mission specialists selected as astronauts since April 1959, 28 are on flight status at the National Aeronautics and Space Administration's Lyndon B. Johnson Space Center, Houston, and 35 Space Shuttle pilots and mission specialists reported to JSC July 1, 1978.

Eight groups of astronauts have been selected. In Group I were the seven Mercury astronauts selected in April 1959. Nine test pilots, Group II, was selected in September 1962. In Group III were 14 pilot-astronauts selected in October 1963. Group IV, the first six scientist-astronauts, was selected in June 1965. In April 1966, 19 pilot-astronauts were selected as Group V. Group VI, 11 scientist-astronauts, was selected in August 1967. Seven Air Force Manned Orbital Laboratory Aerospace Research Pilots (USAF Astronaut designation) joined the NASA pilot-astronaut program in August 1969, as Group VII after MOL program was abandoned; Group VIII was selected in January 1978 as pilots and mission specialists for the Space Shuttle. Forty-one of the total have participated in space flights.

Group VIII included six women (the space program's first for duty in space), four minority representatives (three black); 14 of the candidates are civilians and 21 are military officers.

All astronaut personnel are assigned to the Astronaut Office, CB/L.B. Johnson Space Center, Houston, TX 77058. Astronauts currently on duty as well as those who have left the program may be reached at that address. Two former astronauts are currently serving in the U.S. Senate. They are John H. Glenn (D-Ohio), first American to orbit the Earth, as pilot of Mercury 6 in 1962; and Harrison H. Schmitt (R-New Mexico), Lunar Module Pilot on Apollo 17, the last (1973) of the Apollo mission series. Sen. Glenn was elected in 1974, Sen. Schmitt in 1976.

NASA has no plans for a return voyage to the Moon, either manned or unmanned, nor does it contemplate establishing a space station or settlement on the lunar surface in the foreseeable future, or sending a manned mission to Mars.

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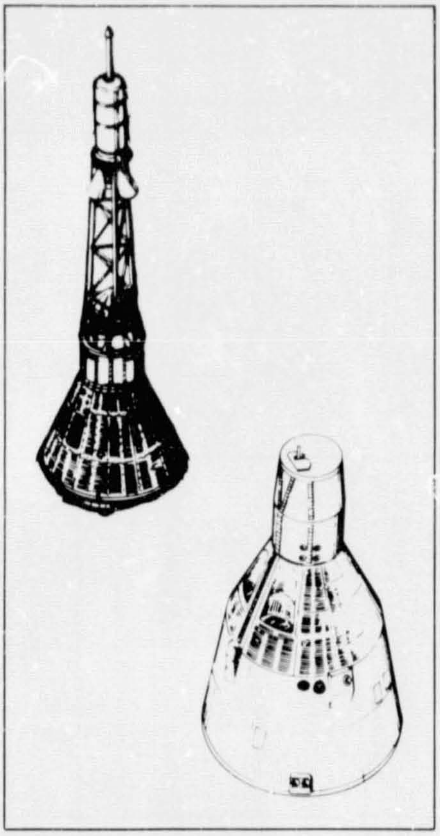
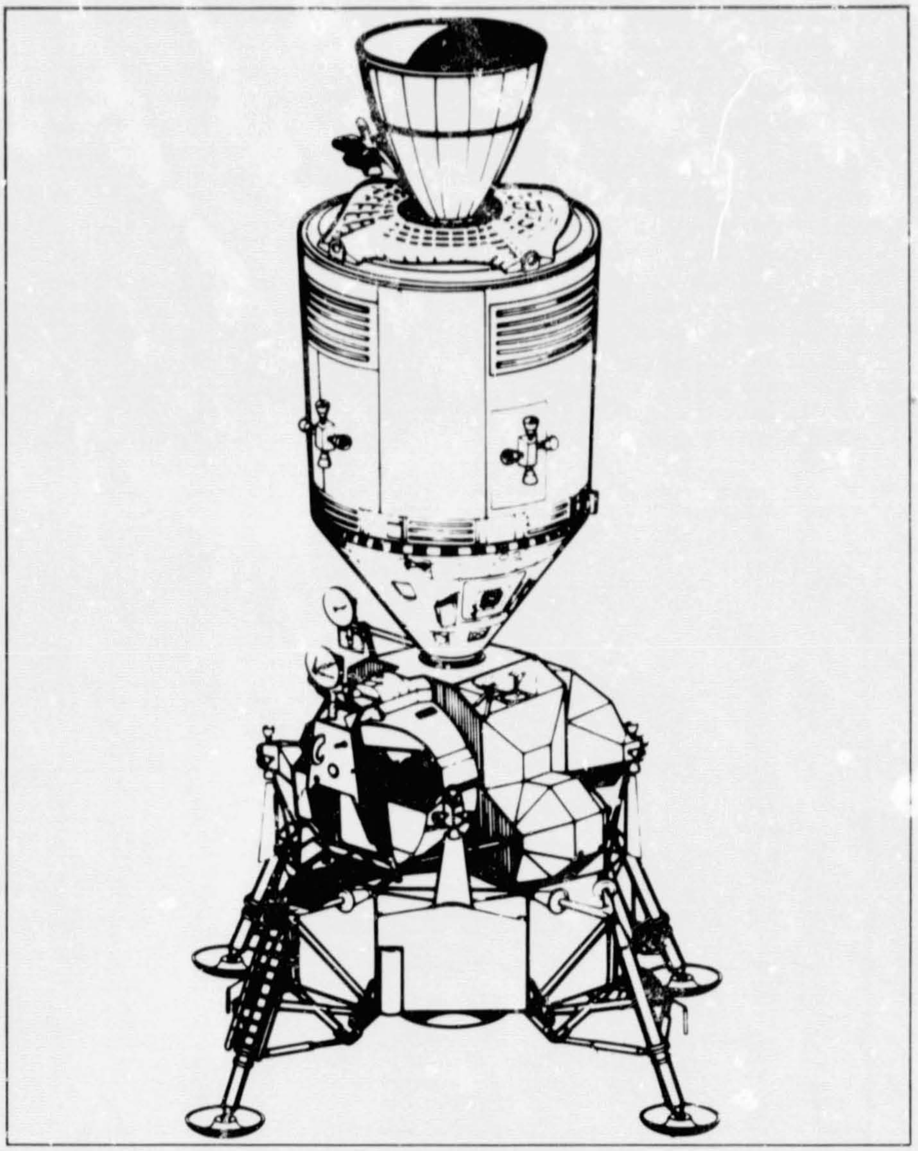
Mercury Gemini Apollo

Mercury
set the trend for U.S. spacecraft design in the first decade. The one-man capsule was 6 feet 10 inches long (26 feet with its launch escape tower) and 6 feet 2-1/2 inches in diameter. It weighed about 2990 pounds in orbit. The blunt end was covered with an ablative heat shield to protect against 3000-degree reentry heat. The capsule was built by McDonnell Douglas Corp.





Gemini
also was built by McDonnell Douglas. The two-man craft was an enlargement of the Mercury vehicle, but experience had shown that much equipment could be placed outside the pressurized cabin and left behind at reentry. Gemini propulsion systems allowed changes in orbit, as well as reentry maneuvers for pinpoint landings. The spacecraft was 19 feet long, 10 feet in diameter, and weighed about 8400 pounds.

Drawings indicate relative sizes of spacecraft.

Apollo Command and Service Modules
bridge the first decade of American manned space flight with the second; they served both Skylab and Apollo/Soyuz Test Project planners. The service module extends the Gemini concept of locating in a separate package the equipment and supplies not needed for reentry, and the three-man command module retains the ablative heat shield of Mercury and Gemini. The command module is 10 feet 7 inches high (to top of apex cover) and 12 feet 10 inches in diameter; its 33-foot launch escape tower is jettisoned before orbital insertion. The service module is 24 feet 9 inches by 12 feet 10 inches. Both modules are built by Rockwell International.

Apollo Lunar Module (LM)
operated only outside the atmosphere. Its shape therefore was dictated by its job of taking two men safely to and from the Moon's surface. The LM was 22 feet 11 inches high with legs extended, 31 feet in diameter (measured diagonally across extended landing gear). Nominal Earth orbit weight of the three Apollo modules was 100,600 pounds. Grumman Aerospace Corp. built the lunar module.

Space Launch Vehicles

Whatever space mission is undertaken, manned or unmanned, the spacecraft carrying the payload must be propelled into space by a rocket. All rockets currently used by NASA have more than one stage and are usually referred to as launch vehicles.

The payload weight and its planned flight path determine what rocket capabilities are required for each mission. Obviously it would not make sense to use a powerful Saturn-type launch vehicle for a relatively small scientific spacecraft when a less powerful vehicle could perform the mission adequately and more economically.

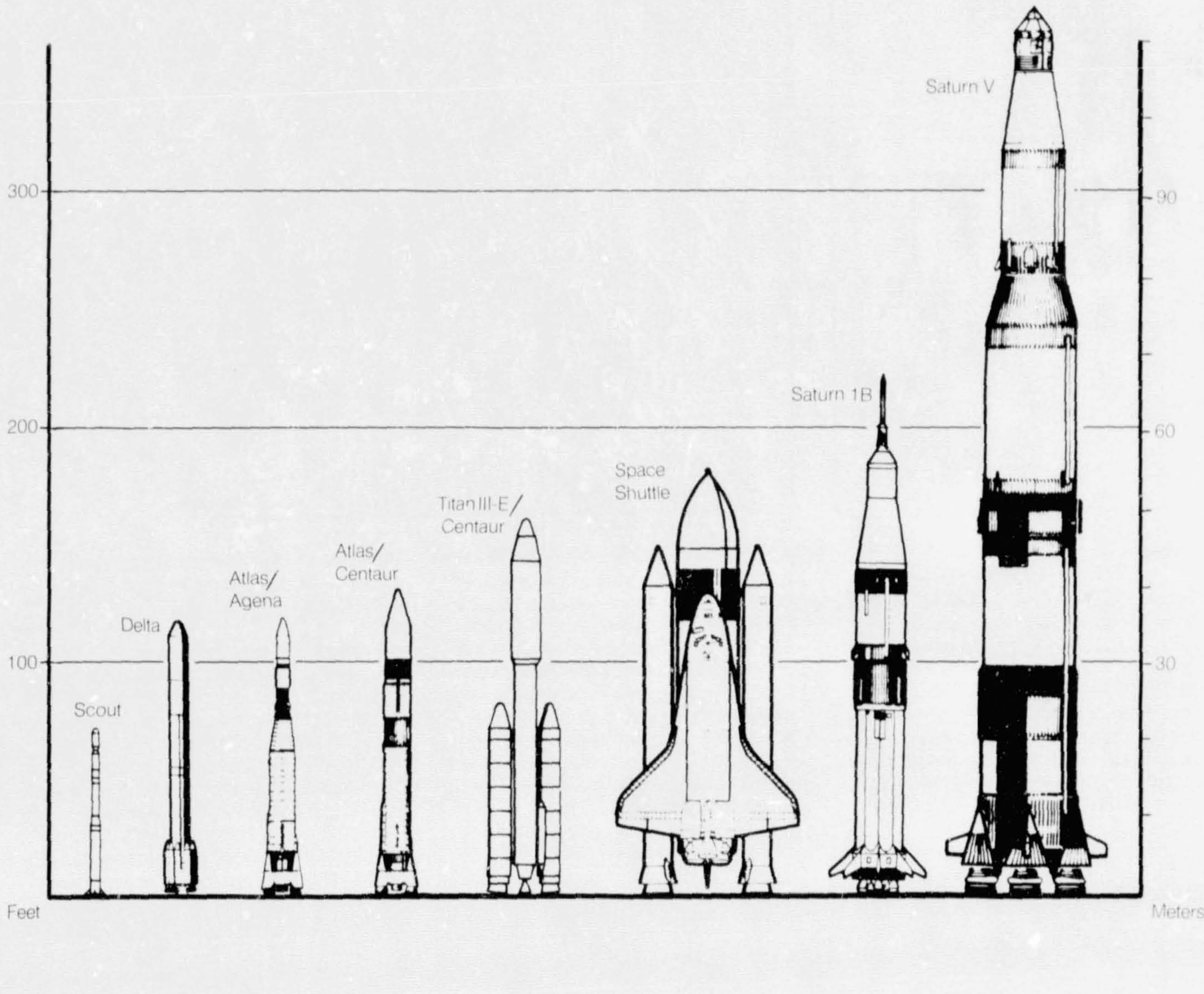
Several launch vehicles used by NASA earlier in the space program are no longer in service. These include the Atlas/Agena, Saturn V, Saturn IB, and Titan III-E/Centaur.

Atlas/Agena

was a multi-purpose two-stage liquid propellant rocket. It was used to place unmanned spacecraft in Earth orbit, or inject them into the proper trajectories for planetary or deep-space probes.

The programs in which the versatile Atlas/Agena was utilized included early Mariner probes to Mars and Venus, Ranger photographic missions to the Moon, the Orbiting Astronomical Observatory (OAO), and early Applications Technology Satellites (ATS). It was also used as the rendezvous target vehicle for the Gemini spacecraft during this series of two-man missions in 1965-66. In preparation for the manned lunar landings, Atlas/Agena launched lunar orbiter spacecraft which went into orbit around the Moon and took photographs of possible landing sites.

The Atlas/Agena stood 36.6 meters (120 feet) high, and developed a total



Space shuttle orbiter mated to external fuel tanks, two solid rocket boosters, atop mobile launcher platform at NASA's Kennedy Space Center, FL.

thrust at lift-off of approximately 1,725,824 newtons (388,000 pounds). It was last used in 1968 to launch an Orbiting Geophysical Observatory (OGO).

Saturn V

America's most powerful rocket, carried out its last scheduled manned mission on December 7, 1972, when it sent Apollo 17 on the final lunar exploration flight. It was last used on May 14, 1973, when it lifted the unmanned Skylab space station into Earth orbit, where it was visited by three crews for a total of 171 days. Saturn V with the Apollo spacecraft stood 111 meters (363 feet) tall, and developed 34.5 million newtons (7.75 million pounds) of thrust at liftoff.

Saturn IB

Was the launch vehicle for the Skylab and Apollo Soyuz Test Project. It was 69 meters (223 feet) tall with the Apollo spacecraft, and developed 7.1 million newtons (1.6 million pounds) of thrust at liftoff.

Titan III-E/Centaur

First launched in 1974, had an overall height of 48.8 meters (160 feet). Designed to use the best features of three proven rocket propulsion systems, this vehicle gave the U.S. an extremely powerful and versatile rocket for launching large spacecraft on planetary missions or into Earth orbit.

The Titan III-E/Centaur was the launch vehicle for two Viking spacecraft to Mars, and two Voyager spacecraft to Jupiter and Saturn. It also launched two Helios spacecraft toward the Sun.

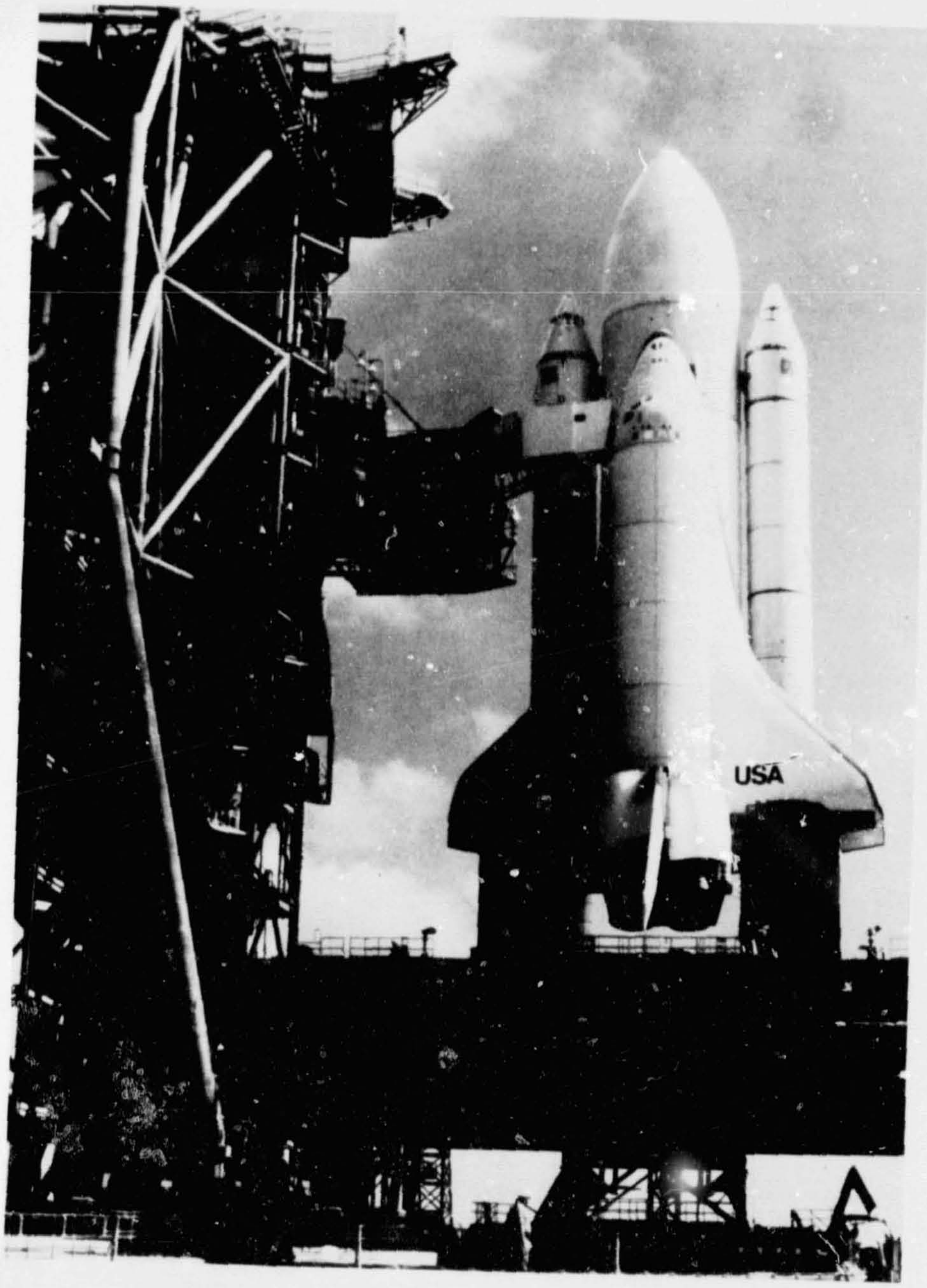
The Titan III-E booster was a two stage liquid-fueled rocket with two large solid-propellant rockets attached. At liftoff, the solid rockets provided 10.7 million newtons (2.4 million pounds) of thrust.

The Centaur stage, still in use today, produces 133,440 newtons (30,000 pounds) of thrust from two main engines, and burns for up to seven and one-half minutes. The Centaur can be restarted several times, which allows for more flexibility in launch times.

Current Launch Vehicles

The Kennedy Space Center continues to launch the Delta and Atlas/Centaur rockets for NASA from the Cape. The Delta launch team also conducts Delta launches from the Western Test Range in California. Scout rockets are launched from Wallops Flight Center, Wallops Island Virginia; the Western Test Range; and the San Marco launch complex off the east coast of Africa, all by launch teams from Langley Research Center.

Many of the launches conducted by NASA are for commercial organizations, other Federal agencies, other nations, or multi-national groups such as the International Telecommunications Satellite Organization. NASA is reimbursed for the cost of the rocket and launch services for such missions.



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U.S. Manned Space Flights (1961-1975)

Program[1]	*Date(s) Recovery Ship*[2]	*Crew*	*Mission Duration*[3]	*Remarks*[4]
Mercury				
Mercury Redstone 3 (Freedom 7)	May 5, 1961 Lake Champlain (A)	Navy Comdr. Alan B. Shepard, Jr.	0:15	suborbital
Mercury Redstone 4 (Liberty Bell 7)	July 21, 1961 Randolph (A)	USAF Maj. Virgil I. Grissom	0:16	suborbital
Mercury Atlas 6 (Friendship 7)	Feb. 20, 1962 Noa (A)	Marine Lt. Col. John H. Glenn	4:55	three orbits
Mercury Atlas 7 (Aurora 7)	May 24, 1962 Pierce (A)	Navy Lt. Comdr. Scott Carpenter	4:56	three orbits
Mercury Atlas 8 (Sigma 7)	Oct. 3, 1962 Kearsarge (P)	Navy Comdr. Walter M. Schirra, Jr.	9:13	six orbits
Mercury Atlas 9 (Faith 7)	May 15-16, 1963 Kearsarge (P)	USAF Maj. L. Gordon Cooper	34:20	22 orbits
Gemini				
Gemini 3 (Molly Brown)	March 23, 1965 Intrepid (A)	USAF Maj. Virgil I. Grissom Navy Lt. Comdr. John W. Young	4:53	three orbits
Gemini 4	June 3-7, 1965 Wasp (A)	USAF Majors James A. McDivitt and Edward H. White, II	97:56	62 revolutions; first U.S. EVA (White)
Gemini 5	Aug. 21-29, 1965 Lake Champlain (A)	USAF Lt. Col. L. Gordon Cooper Navy Lt. Comdr. Charles Conrad, Jr.	190:55	120 revolutions
Gemini 6	Dec. 15-16, 1965	Navy Capt. Walter M. Schirra, Jr.	25:51	Rendezvoused within 1 ft. of Gemini 7
Gemini 7	Dec. 4-18, 1965 Wasp (A)	USAF Lt. Col. Frank Borman Navy Comdr. James A. Lovell, Jr.	330:35	Longest Gemini flight; rendezvous target for Gemini 6
Gemini 8	Mar. 16, 1966 L. F. Mason (P)	Civilian Neil A. Armstrong USAF Maj. David R. Scott	10:41	Docked with unmanned Agena 8
Gemini 9A	June 3-6, 1966 Wasp (A)	USAF Lt. Col. Thomas P. Stafford Navy Lt. Comdr. Eugene A. Cernan	72:21	Rendezvous (3) with Agena 9; one EVA
Gemini 10	July 18-21, 1966 Guadalcanal (A)	Navy Comdr. John W. Young USAF Maj. Michael Collins	70:47	Docked with Agena 10; rendezvoused with Agena 8; two EVAs
Gemini 11	Sept. 12-15, 1966 Guam (A)	Navy Comdr. Charles Conrad, Jr. Navy Lt. Comdr. Richard F. Gordon, Jr.	71:17	Docked with Agena 11 twice; first tethered flight; two EVAs
Gemini 12	Nov. 11-15, 1966 Wasp (A)	Navy Capt. James A. Lovell, Jr. USAF Maj. Edwin E. Aldrin, Jr.	94:35	Three EVAs total 5 hrs. 30 min.
Apollo				
Apollo 7	Oct. 11-22, 1968 Essex (A)	Navy Capt. Walter M. Schirra, Jr. USAF Maj. Donn Eisele Civilian Walter Cunningham	260:09	Tested Apollo Command Module in Earth orbit
Apollo 8	Dec. 21-27, 1968 Yorktown (P)	USAF Col. Frank Borman Navy Capt. James A. Lovell, Jr. USAF Lt. Col. William Anders	147:01	First manned Saturn V launch; 10 lunar orbits
Apollo 9 (Gumdrop and Spider)	March 3-13, 1969 Guadalcanal (A)	USAF Col. James A. McDivitt USAF Col. David R. Scott Civilian Russell L. Schweickart	241:01	Earth orbital mission; first manned flight of LM; 2 EVAs total 2 hrs. 8 min.

Program[1]	Date(s) Recovery Ship[2]	Crew	Mission Duration[3]	Remarks[4]
Apollo 10 (Charlie Brown and Snoopy)	May 18-26, 1969 Princeton (P)	USAF Col. Thomas P. Stafford Navy Comdr. John W. Young Navy Comdr. Eugene A. Cernan	192:03	31 lunar orbits; LM descended to within 9 miles of lunar surface
Apollo 11 (Columbia, Eagle)	July 16-24, 1969 Hornet (P)	Civilian Neil A. Armstrong USAF Lt. Col. Michael Collins USAF Col. Edwin E. Aldrin, Jr.	195:19	First manned lunar landing; Sea of Tranquility; 1 lunar EVA 2 hrs. 48 min.; 46 lbs. lunar samples
Apollo 12 (Yankee Clipper and Intrepid)	Nov. 14-24, 1969 Hornet (P)	Navy Comdr. Charles Conrad, Jr. Navy Comdr. Richard F. Gordon, Jr. Navy Comdr. Alan L. Bean	244:36	Landed Ocean of Storms; 2 lunar EVAs total 7 hrs. 46 min.; 75 lbs. samples
Apollo 13 (Odyssey and Aquarius)	April 11-17, 1970 Iwo Jima (P)	Navy Capt. James A. Lovell, Jr. Civilian Fred W. Haise, Jr. Civilian John L. Swigert, Jr.	142:55	Lunar landing aborted after oxygen tank ruptured; safe recovery
Apollo 14 (Kitty Hawk and Antares)	Jan. 31-Feb. 9, 1971 New Orleans (P)	Navy Capt. Alan B. Shepard, Jr. USAF Maj. Stuart A. Roosa Navy Comdr. Edgar D. Mitchell	216:02	Landed Fra Mauro; 2 lunar EVAs total 9 hrs. 23 min., 94 lbs. samples
Apollo 15 (Endeavour and Falcon)	July 26-Aug. 7, 1971 Okinawa (P)	USAF Col. David R. Scott USAF Lt. Col. James B. Irwin USAF Maj. Alfred M. Worden	295:12	Landed Hadley Apennine; 3 lunar EVAs total 18 hrs. 35 min.; 169 lbs. samples
Apollo 16 (Casper and Orion)	April 16-27, 1972 Ticonderoga (P)	Navy Capt. John W. Young Navy Lt. Comdr. Thomas K. Mattingly, II USAF Lt. Col. Charles M. Duke, Jr.	265:51	Landed Descartes highlands; 3 lunar EVAs total 20 hrs. 14 min.; 207 lbs. samples
Apollo 17 (America and Challenger)	Dec. 7-19, 1972 Ticonderoga (P)	Navy Capt. Eugene A. Cernan Navy Comdr. Ronald E. Evans Civilian Harrison H. Schmitt (Ph.D.)	301:52	Landed Taurus-Littrow; 3 lunar EVAs total 22 hrs. 4 min.; 243 lbs. samples
Skylab				
Skylab 1	Launched May 14, 1973 Unmanned		Remained in orbit	100-ton space station visited by three crews
Skylab 2	May 25-June 22, 1973 Ticonderoga (P)	Navy Capt. Charles Conrad, Jr. Navy Comdr. Paul J. Weitz Navy Comdr. Joseph P. Kerwin (M.D.)	28 days 50 min.	Repaired Skylab; 404 revolutions; 392 experiment hours; 3 EVAs total 5 hrs. 34 min.
Skylab 3	July 28-Sept. 25, 1973 New Orleans (P)	Navy Capt. Alan L. Bean Marine Maj. Jack R. Lousma Civilian Owen K. Garriott (Ph.D.)	59 days 11 hrs. 9 min.	Performed maintenance; 858 revolutions; 1081 experiment hours; 3 EVAs total 13 hrs. 42 min.
Skylab 4	Nov. 16, 1973-Feb. 8, 1974 New Orleans (P)	Marine Lt. Col. Gerald P. Carr USAF Lt. Col. William R. Pogue Civilian Edward G. Gibson (Ph.D.)	84 days 1 hr. 16 min.	Observed Comet Kohoutek; 1214 revolutions; 1563 experiment hours; 4 EVAs total 22 hrs. 25 min.
ASTP				
Apollo Soyuz Test Project	July 15, 1975-July 24, 1975 New Orleans (P)	USAF Brig. Gen. Thomas P. Stafford Civilian Vance D. Brand Civilian Donald K. Slayton	217:28	Apollo docked with Soviet Soyuz spacecraft July 17; separated July 19

1. Names in parentheses are crew names for spacecraft or Command and Lunar Modules
2. (A) or (P) denotes Atlantic or Pacific Ocean splashdown
3. Hours and minutes, except for Skylab
4. EVA refers to extravehicular activity, or activity outside the spacecraft
5. Flown by Cosmonauts Aleksey A. Leonov and Valeriy N. Kubasov

Totals: flights-31; astronauts participating-43; cumulative man hours in space-22,503:49

Apollo Soyuz Test Project

First International Manned Space Flight

July 15-24, 1975

The Crews

Apollo Commander—Thomas P. Stafford, Maj. Gen. USAF

Command Module Pilot—Vance D. Brand

Docking Module Pilot—Donald K. Slayton

Soyuz Commander—Alexey A. Leonov, Brig. Gen. Soviet Air Force

Flight Engineer—Valeriy H. Kubasov

Mission Duration—Nine days, eight hours, 18 minutes from Soyuz launch to Apollo landing

Objective of Mission

The Apollo Soyuz Test Project mission was planned to accomplish spacecraft rendezvous, docking, undocking, crew transfer, interaction of control centers, and interaction of spacecraft crews.

The development of the compatible docking systems enhances the safety of manned flights in space and provides the opportunity for conducting joint experiments in the future. The new docking system also provides the basis for a standardized international system for docking of manned spacecraft.

(All Mission Objectives Were Accomplished)

Costs of Major Manned Projects

Mercury

Spacecraft	135,300,000
Launch Vehicles	82,900,000
Operations	49,300,000
Tracking Operations and Equipment	71,900,000
Facilities	53,200,000
Total	$392,600,000

Gemini

Spacecraft	797,400,000
Launch Vehicles	409,800,000
Support	76,200,000
Total	$1,283,400,000

Apollo

Estimated total cost of Apollo Program through completion	$25 billion

Skylab Program

Total cost of program	$2.6 billion

Apollo Soyuz Test Project

Total cost of program (U.S.)	$250 million

Space Shuttle Project*

Total cost of Design, Development, Test and Evaluation (DDT&E)	$6.9 billion
Includes two orbiters	(1976 dollars)

*Please see FY 1980 NASA Budget Request.

Apollo and Soyuz docked

10th Anniversary of Apollo 11 Man on the Moon

At 10:56 P.M. EDT, Sunday, July 20, Astronaut Neil A. Armstrong, spacecraft commander of Apollo 11, set foot on the moon. His descent from the lowest rung of the ladder which was attached to a leg of the lower stage of the Lunar Module (LM), to the footpad, and then to the surface of earth's only natural satellite constituted the climax of a national effort that began in 1961. It was an effort that involved, at its peak, more than 300,000 people in industry, the universities and in government.

As he took his epochal step, Armstrong commented, "That's one small step for a man, one giant leap for Mankind."

Sharing this electric moment with Armstrong and Edwin "Buzz" Aldrin, the LM pilot, were an estimated half-billion TV watchers in most of the earth's nations. As the astronaut descended the ladder he pulled, a "D" ring that deployed a black and white television camera which was focused to record the event. Framed by parts of the LM's under-carriage, Armstrong's heavily-booted left foot descended across millions of TV tubes until his boot sole made contact.

Work on The Moon

With the post landing checks completed, Armstrong climbed out of the LM and descended to the lunar surface. The moon walk began more than five hours ahead of schedule as a result of deciding not to have a rest period on schedule. Armstrong's attention was first directed at the nature of the surface material. He reported that the top layer was a fine, powdery material. He noted that he sunk in only a quarter of an inch or less, and that the footpads of the LM, which are convex discs 32 inches in diameter, had penetrated only a few inches. He also observed that the exhaust of the descent engine had not cratered the area directly below the LM engine nozzle.

After a quick visual check of the LM, Armstrong went ahead with his scheduled task of collecting the contingency sample—several pounds of lunar surface material which he stowed in a spacesuit pocket.

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Astronaut footprint on the moon July 20, 1969

Astronauts Armstrong, Collins, and Aldrin

Aldrin Leaves the LM

Once the LM inspection and the sample collection were completed, Aldrin got out of the LM and climbed down the ladder, with Armstrong providing voice guidance. Armstrong was taking pictures of the event at the same time. The two then "unveiled" the plaque mounted on the strut behind the ladder by removing a protective covering. They read the inscription for the benefit of their world audience.

"Here Men From Planet Earth
First Set Foot Upon The Moon
July 1969 A.D.
We Came In Peace For All Mankind"

"We stand here in the dusk, the cold, the silence and here, as at the first of time, we lift our heads."
(From his poem Voyage To The Moon)
Archibald MacLeish

Records and Firsts

As might be expected from the nature of the mission, Apollo 11 established a number of records and "firsts." It put the largest payload ever in lunar orbit. In the 8-day mission, the TV networks beamed abroad, via satellite, telecasts totaling 230 hours. Comsat estimated viewers totaled 500 million. It was the healthiest flight. None of the crew had to resort to the medical kit for any reason. All phases of the lunar touchdown, the moon walk, and the ascent to 50,000 feet were "firsts." A record number of people watched the launch. Civil Defense officials estimated 1,000,000 watchers pitched tents on nearby beaches and dunes, filled the motels and hotels and created a massive traffic tie-up. More than 3,000 newsmen from 55 countries besides the U.S. were on hand to report the event. Japanese media alone were represented by more than 100 correspondents.

Report On The Lunar Surface

Armstrong removed the TV camera that had covered his first step on the moon and transmitted several panoramic shots of the area surrounding the LM. The pictures came through with remarkably good definition and showed a fairly level area pitted with small craters. There was a scattering of boulders of varying sizes and shapes, some of them as large as two feet in their biggest visible dimension.

The astronauts described the surface color as varying from a very light to a dark grey. When in the spacecraft, Armstrong reported seeing some boulders that had apparently been fractured by the exhaust of the descent engine. Their surface was a light grey—perhaps coated with the powdery surface material. The fractures were very much darker. From the astronauts' comments, it appeared that the sun angle was a factor in color.

The crew then deployed a specially structured 3' x 5' American flag. They fitted together its two-piece aluminum staff and deployed a support along its upper edge so that it would remain unfurled in the lunar vacuum.

Foreign Reaction

Interest in Apollo 11 was intense and worldwide. The heads of state of 74 nations sent message of Godspeed and good luck. By a microdot process, these were reduced 200 times so that they all fitted on a silicon disc about the size of a silver dollar. Although each message is no larger than the head of a common pin, they remain readable under a microscope. The disc was left on the moon.

Besides three American flags, the crew carried with them the flags of the 50 states, of U.S. territories, of the United Nations and of each nation diplomatically recognized by the United States. Two American flags were brought back for presentation to the Senate and the House of Representatives.

The crew also had with them medals in memory of Astronauts Grissom, Chaffee and White who were to have been the crew of the first manned space flight in the Apollo program.

They also left a memorial for the two Russian cosmonauts who were killed.

British insurance underwriters, Lloyds of London, rang the Lutine Bell, only done on rare occasions, to celebrate the success of the mission. Czechoslovakia and a number of other foreign nations, including the tiny Maldive Islands, issued special postage stamps. Several hundred Poles crowded into the lobby of the U.S. Embassy in Warsaw to watch the telecast of the moon walk. Applause was frequent during the transmission, and congratulations flowed freely. Among those cabling congratulations to President Nixon were Pope Paul VI, UN Secretary General U Thant, and Soviet President Nikolai V. Podgorny. Moscow radio began its 8 P.M. newscast with the term "Flash" and then reported that word of the completion of the Apollo mission had just come in and that "The courageous astronauts, Armstrong, Aldrin and Collins are again on our planet."

On the personal side, a Peruvian mother named her baby, born during the flight, after Neil Armstrong.

Thus, in 195 hours, 18 minutes and 35 seconds, Apollo 11 and Astronauts Armstrong, Aldrin and Collins moved the world into a new era.

Solar System

The nine known planets of the solar system can be divided into two categories: the Jovian planets and the terrestrial planets. Jupiter, Saturn, Uranus, and Neptune, the Jovian planets, are believed to consist of large cores of solid hydrogen and heavier elements surrounded by extensive atmospheres of heavy gases. As a group, the Jovian planets are less dense than the terrestrial planets and have many more satellites. Mercury, Venus, Earth, Mars, and Pluto, the terrestrial planets, are dense, solid bodies without extensive atmospheres. Between the orbits of Mars and Jupiter, the majority of asteriods, of which over 1,600 are presently known, are situated. These diminutive objects are thought to be remnants of a large planet which disintegrated. The planets travel in elliptical orbits of relatively low eccentricity around the Sun, although the eccentricity of Pluto is large enough to bring it sometimes nearer the Sun than Neptune. All the planets lie close to the plane of the earth's orbit, the ecliptic. Except for Pluto, the terrestrial planets are much nearer the Sun than the Jovian planets.

Earth and Moon

The Earth is slightly flattened at the poles, resulting in an equatorial bulge. Energetic protons, and electrons, trapped above the atmosphere by the Earth's magnetic field, form the Van Allen belts. The Moon has no atmosphere, and its cratered surface is believed caused by primordial meteorite impact and volcanic activity.

Sun

Our Sun, an incandescent body of gas, is by far the largest and most massive object in the solar system. Sunspots are large areas of cooler gas viewed against the hotter gas of the Sun's surface. Huge gaseous eruptions, known as prominences, sometimes rise several hundred thousand miles above the solar surface.

Milky Way

This immense aggregate of millions of stars, comprised of a flattened ellipsoid of stars with a very dense nucleus and superposed spiral arms, is 100,000 light years in diameter. The Sun, a typical star 30,000 light years from the center, is located in a spiral arm and moves with a speed of 250 miles per second around the galactic center.

Apollo 17 lifted off in darkness.

The Stars

Lifestyles of the Stars

Pulsars, X-ray sources, black holes, novae, and neutron stars. All of these and more are part of the fantastic universe and the new astronomy, a revolutionary view of the Universe in which observations appear to confirm seemingly incredible theory.

Much of this increased knowledge has been synthesized into a fascinating theoretical scenario of the births, lives, and the several kinds of bizarre deaths of stars. Their stories follow:

Star Birth

Stars are believed to originate in enormous clouds of dust and (mostly hydrogen) gas. There are many such clouds in our Universe. They are as-

sumed to contain nearly all of the matter between the stars.

Gravity is a key to star evolution. You may recall that according to Newton's law of gravity, all bodies, from the largest objects to the smallest particles in the Universe, attract each other. Thus, the gas and dust particles of the vast interstellar clouds exert gravity upon one another. Eventually, enough particles in a cloud may coalesce to form a clump that is massive enough to be gravitationally bound. At this point, the cloud collapses under the influence of its own gravity.

At first, it contracts rapidly because energy thereby released is easily radiated outward. Eventually, the cloud grows dense enough to become opaque to (block) its own radiation. This causes the cloud to heat up, slowing down but not stopping its contraction. The cloud's continued collapse leads to additional heating of its interior.

Eventually, the center of the cloud grows so hot that thermonuclear fusion, in which hydrogen is converted to helium and radiant energy, occurs. Nuclear rather than gravitational energy then becomes the source of the cloud's heat. The cloud's collapse is then halted because outward pressures of nuclear-heated gases balance the inward forces of gravity. Thus, a main sequence star (one in the stage of its evolution when it burns hydrogen in its core, like our Sun) is born.

Are stars still being born? Astronomers studying dense interstellar clouds with infrared (heat-sensitive) instruments have discovered an abundance of glowing objects, hidden by the clouds from optical telescopes, that appear to be developing (pre-main sequence) stars.

Main Sequence Stars

How long a star remains a main sequence, or hydrogen-burning, star, like our Sun and most others visible in the heavens, depends largely upon its mass. Our Sun has a main sequence lifetime of about ten billion years, of which approximately five billion have already passed. Larger stars burn faster and hotter than our Sun and have main sequence lifetimes of as little as a million years.

Red Giants

When the hydrogen fuel in a star's core is consumed, the core starts to collapse. At the same time, nuclear reactions that convert hydrogen into helium, releasing energy, move outward from the core into regions where unused hydrogen exists.

The intense heat of the nuclear reactions in a shell around the core causes the star's outer envelope to expand. As it expands, it cools, and the star's surface color becomes a deep red. The star is now a Red Giant. When this happens to our Sun, it will grow into a vast sphere, eventually engulfing the nearby planets, Mercury and Venus, and possibly Earth and Mars.

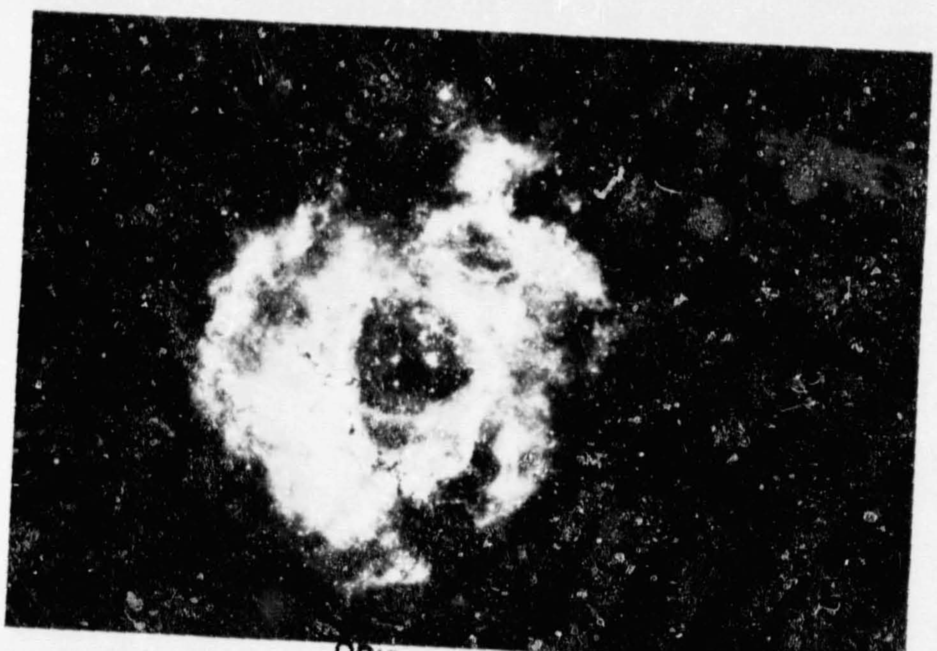
In the meantime, the contracting core may grow so hot that it ignites and burns nuclear fuels other than hydrogen, beginning with helium. The star's subsequent behavior is complex, but, in general, it can be characterized as a sequence of gravitational contractions and nuclear ignitions. Each nuclear ignition and burning produces a succession of heavier elements in addition to releasing energy; for example, burning of helium produces carbon and burning of carbon produces oxygen. Most important from the standpoint of our story is that after exhausting each nuclear fuel, the star tries to stay alive by further contraction of its core and burning the next available nuclear fuel. Because the available nuclear fuels are limited, the star cannot continue the process indefinitely, so eventually it must die. Depending upon its mass, it may finally come to rest as a White Dwarf, Neutron Star, or Black Hole.

White Dwarfs

When all the nuclear fuels it can burn are consumed, a star comparable to our Sun (Most stars are believed to be in this category) contracts to a white hot sphere as small as a planet. Such an object is called a White Dwarf. The White Dwarf's atoms are packed so tightly together that a sugar-cube-sized fragment of it would weigh thousands of kilograms. Over billions of years, the White Dwarf cools and fades to a black cinder. Such is the future of our Sun and the majority of other stars.

Neutron Stars

In a star more than about 1½ times the mass of the Sun, gravitational forces are of such magnitude that they overcome the collective electron pressure which halts the collapse of smaller stars. The core's collapse may continue until its density is so high that its electrons are driven into atomic nuclei which are then



'Rosette' Nebula in Monoceros

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transmuted into neutrons, creating in effect an atomic nucleus of astronomical proportions—a neutron star.

A neutron star may be as small as 20 kilometers (12 miles) in diameter, with a density billions of times that of lead. A cubic centimeter of its matter could weigh billions of kilograms on Earth. Its density has been described as equivalent to that which would result if all the world's automobiles were compressed and packed into a thimble.

Most astronomers today associate the astronomical phenomena called supernovae and pulsars with neutron stars and their evolution. The phenomena are:

Supernovae

A star's final collapse to the neutron star stage may give rise to physical conditions that cause its outer portions to explode, producing what we call a supernova. A supernova can temporarily outshine all of the hundreds of millions of ordinary stars in its galaxy.

A supernova explosion fills vast regions of space with matter which may radiate energy (including visible light) for hundreds and even thousands of years. An example of the remnant of a supernova explosion is the Crab Nebula, mentioned in *Pulsars*, below.

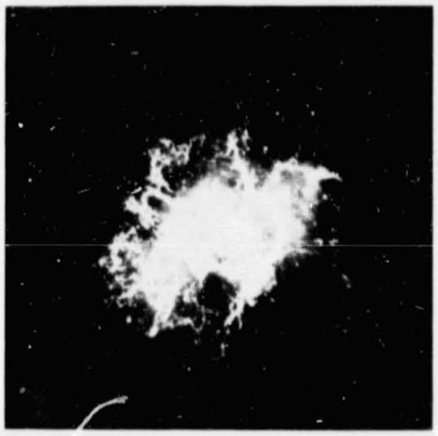
The material expelled by a supernova may recondense into one or more new stars. It is possible that our Sun may have originated in the debris of a supernova. This is because it contains larger amounts of heavy elements (such as iron), which are thought to be produced in supernova explosions, than are typical of first generation stars.

Supernovae should not be confused with novae. Novae are far gentler occurrences. One common class of novae—called recurrent novae—is due to the nuclear ignition of gas being dumped from time to time on the hot surface of a White Dwarf from a companion star in a binary system. (Binary systems, in which two stars revolve around each other, are commonplace in our Universe).

Pulsars

The pulsar, which was discovered by radio astronomers and was so named because its radio signal regularly turns on and off (pulses), is thought to be a spinning neutron star. A pulsar may also pulsate in X-ray and other wavelengths. The pulsar's beams probably do not turn on and off. Instead, the energy is believed to be emitted from a point on the star that faces toward and away from Earth as the star spins, somewhat like the effect of the rotating beacon of a lighthouse.

The only visible pulsar is the central object of the Crab Nebula, a vast glowing cloud of gas. The pulsar and nebula are remnants of the supernova of 1054 that was observed and reported by ancient Chinese astronomers.



Crab Nebula

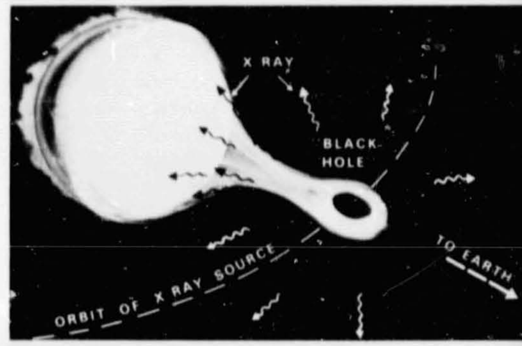
Black Holes

The end product of the gravitational collapse of a star that is more than about 3 times the mass of our Sun may appear to be fantasy. Such a dying star shrinks with increasing rapidity, cracks the neutron barrier, and disappears from sight, literally creating a black hole in space. The black hole is aptly named. Nothing—not even light—can escape its incredible gravitational pull.

It would seem that a black hole could remain invisible and undetected. However, if it is part of a binary star system, evidence for a black hole's existence could be acquired by studying its gravitational effects on its visible companion. (See below.) In addition, theorists have concluded that a substantial amount of the matter transferred from the binary companion to the black hole should be converted into hard (extremely penetrating) and soft (less penetrating) X-rays and into gamma rays that are radiated into space and can be detected. These emissions, it should be emphasized, are not from the black hole but from the hole's effect on matter being pulled into it before the matter reaches the point of no return.

In November 1973, a team of astronomers at London's University College claimed they had solid evidence of the type described above for the existence of a black hole. Using data from an X-ray experiment aboard NASA's Orbiting Astronomical Observatory (named for the great Polish astronomer Copernicus) they studied a mysterious powerful X-ray source called Cygnus X-1.[1]

The London team first identified the



Black Hole

Cygnus X-1 source with the binary super giant star system HDE (for Henry Draper Extension catalog) 226868, which is in our Milky Way galaxy and some 8000 light years,[2] from Earth. Optical observations indicated that the system consisted of a visible supergiant star 30 times as massive as our Sun and an invisible companion.

According to the astronomers, vast clouds of glowing matter are being ripped from the visible star by its invisible companion. A good part of this matter is being converted into the

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[1]An X-ray source is defined as a celestial phenomenon that radiates more X-rays than any other form of electromagnetic radiation. (Other forms of electromagnetic radiation: visible light, infrared rays (heat), gamma rays, ultraviolet light, and radio waves.) In contrast, X-rays are only a small part of the electromagnetic radiation of normal stars like our Sun. Cygnus X-1 is so named because it is the first X-ray source discovered in the constellation Cygnus, the Swan.

[2]A light year is an astronomical yardstick equal to 9.6 trillion kilometers, or 6 trillion miles.

theoretically predicted X-rays as it is pulled toward the invisible object.

In addition, Copernicus data show that cessations of soft X-ray emissions from the system apparently coincide with time intervals when the visible star would be in front of the invisible object relative to Earth (The visible star and its invisible companion, as in any binary system, revolve around each other). Soft X-rays are absorbed as they pass through the atmosphere of the visible star. In contrast, hard X-rays from the direction of the invisible object traverse the visible supergiant's atmosphere without being dimmed and do not display such periodic variations.

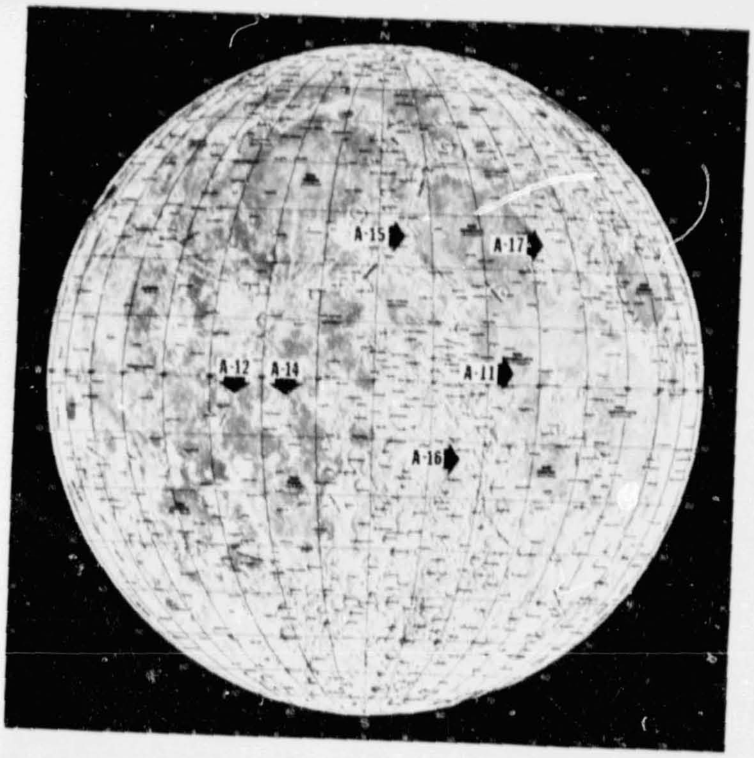
Furthermore, by analyzing the gradual cut-off of the soft X-ray emissions, the astronomers were able to estimate the unseen object's size as one ten-thousandth that of our Sun. And by calculating in detail how Cygnus X-1's gravity affects the visible star, the astronomers computed Cygnus X-1's mass as about 6 times that of our Sun. This mass exceeds the theoretically predicted limit of a stable neutron star.

Thus, Cygnus X-1's invisibility, great mass, small size, and the hard X-rays apparently streaming from surrounding matter support the conclusion that it is a black hole. The black hole in time may even swallow up its visible companion, leavnig no trace of either's existence.

Revolutionary Advances in Knowledge

The discoveries about stars and our Universe made in recent years are as revolutionary as the advances in astronomy made by Galileo. Much of their significance cannot be determined at this time. But like all advances in knowledge, these are expected eventually to contribute substantially to mankind's benefit.

Apollo landing sites



Apollo Expeditions to the Moon

The Sampling of the Moon

Arrows indicate the locations from which lunar samples have been returned to the Earth for scientific study. The "A" symbols mark the landing sites of the Apollo 11 through Apollo 17 missions. (The Apollo 13 mission did not land. Enroute to the Moon, an oxygen tank exploded; the crew returned safely to Earth.) The "L" symbols indicate the sites near the eastern edge of the Moon from which Russia's automated landers, Luna-16 and Luna-20, returned small samples of lunar soil.

Space Shuttle Profile

The Space Shuttle is a reusable space vehicle which will operate between the ground and Earth orbit. It is the principal element of a Space Transportation System which will provide routine access to space beginning in the 1980's. It will provide low-cost space operations for Earth resources, scientific, defense and technological payloads. It will be able to retrieve payloads from orbit for reuse; to service or refurbish satellites in space; to carry to orbit, operate, and return space laboratories and to perform rescue missions. It will result in savings in the cost of space operations while greatly increasing the flexibility and productivity of the missions.

The Orbiter, workhorse of the Space Shuttle program, is designed to be used a minimum of 100 times. It is as big as a commercial jetliner (DC-9); its empty weight is 68,000 kg (150,000 lb.); it is 37.2 m (122 ft.) in length and it has a wingspan of 23.8 m (78 ft.). The Orbiter is to be launched into low Earth orbit in 1979, with its three main engines being augmented by a pair of solid rocket boosters.

Four two-man crews have been selected to begin training for the early orbital flights of the Space Shuttle. They are:

John W. Young, 47, commander; *Robert L. Crippen*, 40, pilot; *Joe H. Engle*, 45, commander; *Richard H. Truly*, 40, pilot; *Fred W. Haise*, 45, commander; *Jack R. Lousma*, 42, pilot; *Vance D. Brand*, 46, commander; *Charles G. Fullerton*, 41, pilot.

Young and Crippen will be the prime crew for the first orbital flight test

(OFT-1) scheduled for launch from NASA's Kennedy Space Center, Fla., no earlier than November 9, 1979.

Young is Chief of the Astronaut Office and a veteran of four space flights. He was pilot of the first manned Gemini flight, Gemini 3, in 1965; command pilot of Gemini 10 in 1966; command module pilot of Apollo 10 in 1969; and commander of Apollo 16, a lunar landing mission in 1972. He has been a member of four backup crews. Young, a retired Navy captain, has been an astronaut since 1962.

Crippen will be making his first space flight. A Navy commander, he has been a NASA astronaut since 1969 when he was transferred from the cancelled USAF Manned Orbiting Laboratory program. Crippen was a crew member of the Skylab Medical Experiments Altitude Tests (SMEAT), a 56-day simulation of a Skylab mission. He was a member of astronaut support crews for Skylab and Apollo Soyuz Test Project missions.

Space Shuttle Passengers: A Clarification

NASA is not accepting—contrary to news reports—reservations for "passengers" on the Space Shuttle. Non-astronaut "payload specialists" may be aboard some missions to conduct experiments and operate equipment, but there is no available space to allocate to travelers without a crew or payload assignment.

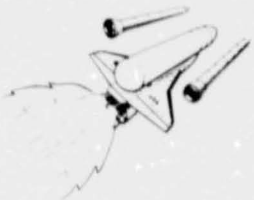
Profile of Shuttle Mission

Each Shuttle orbiter can fly at least 100 missions and carry as much as 29,484 kg (65,000 pounds) of cargo and up to seven crew members and passengers/specialists into orbit. It can return 14,515 kg (32,000 pounds) of cargo to earth.

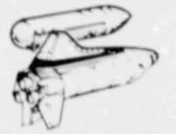
Earthly Payoff Tomorrow

Man goes into space to explore the unknown—to increase our understanding of the past, present, and future of the universe and humanity's place in it. When the Space Shuttle becomes operational in 1980, it will be an important tool to provide mankind with information to help in managing and preserving our crowded Earth. Users of the versatile Shuttle system will include communications networks, research foundations, universities, observatories, federal departments and agencies, state agencies, county and city planners, public utilities, farm cooperatives, the medical profession, the fishing industry, the transportation industry, and power generation and water conservation planners.

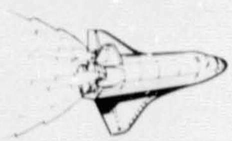
Payloads launched by the Space Shuttle will provide practical data that will affect both the daily lives of people and the long-term future of mankind.



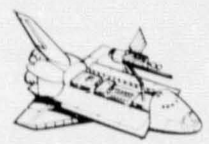
Separation of
Solid-Rocket Boosters
Height: 43 km (27 miles)



Separation of
External Tank

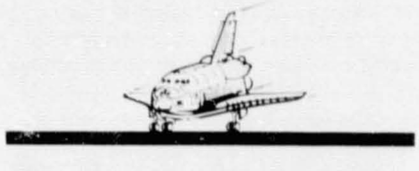


Orbit Insertion and
Circularization
Height: 185 km
(115 miles—typical)



Orbital Operations
Duration: 7-30 days

Atmospheric Entry
Velocity: 28,082 km/hr
(17,450 mph)



Landing

Crossrange: ±2037 km (±1100 nautical miles)
(from entry path)
Velocity: 341-364 km/hr (212-226 mph)

Shuttle Characteristics (values are approximate)

Length

System: 56.14 m (184.2 feet)
Orbiter: 37.24 m (122.2 feet)

Height

System: 23.34 m (76.6 feet)
Orbiter: 17.27 m (56.67 feet)

Wingspan

Orbiter: 23.79 m (78.06 feet)

Weight

Gross Lift-Off:
1,995,840 kg (4.4 million pounds)

Orbiter Landing:
84,778 kg (187 thousand pounds)

Thrust

Solid-Rocket Boosters (2):
12,899,200 newtons (2.9 million pounds) of thrust each at sea level

Orbiter Main Engines (3):
1,668,000 newtons (375 thousand pounds) of thrust each at sea level

Cargo Bay

Dimensions:
18.28 m (60 feet) long, 4.57 m (15 feet) in diameter

Accommodations:
Unmanned spacecraft to fully equipped scientific labs

Shuttle Names, First Launching Date

Selected from sea vessels used in world exploration, names of the first four orbiting Space Shuttle craft are "Columbia," "Challenger," "Discovery" and "Atlantis." "Columbia" is scheduled for launch no earlier than November 9, 1979 from Kennedy Space Center, FL

on a test mission of just over two days' duration. It will land at NASA's Dryden Flight Research Center, CA.

*Space Settlements, Other Usages**

A number of newspapers, magazines, technical journals and other publications have, in the past few years, reported on various aspects of establishing settlements and other utilizations of space, including manufacturing facilities and satellites to transmit solar energy to Earth. Most of the articles differ as to cost, the technology required, the time frame and the size and functional capabilities of individual or cluster settlements.

1. Space settlements are no longer being studied by NASA. A workshop study was conducted in 1975 to explore the space settlement concept.

2. Establishing settlements in space would be very costly. Both the hardware required and the technology needed have not been developed. The number and background training of people to occupy a settlement is unknown.

3. *There is within NASA no recognizable need for a space settlement project now or in the near future.*

4. NASA has no plans at this time to establish a space station on the lunar surface.

Available for those interested in the subject is "Space Settlements—A Design Study," a 185-page, fully-illustrated book, from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, $5.00, stock number 033-000-00669-1.

***Note:**

The President's 1978 U.S. Civil Space Policy precludes for the foreseeable future NASA's undertaking projects of the magnitude of *manned* planetary missions or the establishment of space settlements and allied facilities. NASA's only scheduled manned flight activity in the coming years is the Space Shuttle, scheduled for orbital tests beginning in late 1979, and for operational use in the 1980s. NASA has no plans to return to the Moon with either manned or unmanned craft.

Spacelab

In the 1980's reasonably healthy men and women of many nations who need to go into space to conduct important scientific and technical experiments will be provided that opportunity through Spacelab. Spacelab supplies experimenters with a fully furnished laboratory adapted for the weightless environment of space and pressurized for working without spacesuits.

Spacelab development is financed by 10 European nations under agreements concluded with the European Space Agency (ESA).

Spacelab will be carried in the cargo bay of the Space Shuttle Orbiter, the element of the Shuttle that is piloted into Earth orbit to conduct assigned activities and afterwards is brought back to Earth, landing like an airplane. The Shuttle is scheduled to begin *operational* round trips between the ground and Earth orbit in 1980. Permitting comparatively easy and frequent access to space for people, equipment and spacecraft, it is also expected to reduce the expense and increase the benefits of space operations.

Developed on a modular basis, Spacelab can be varied to meet specific mission requirements. Its two principal components are the pressurized *module* which provides a laboratory with a shirt-sleeve working environment and the open *pallet* that exposes materials and equipment directly to space. Each module is segmented, permitting additional flexibility.

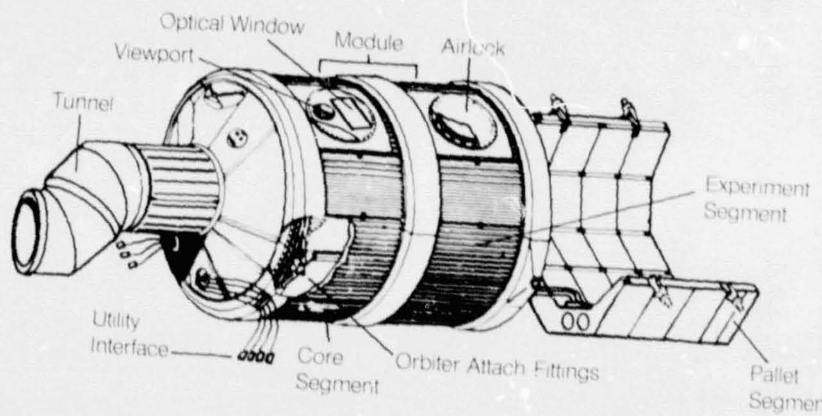
Principal Components of Spacelab.

The pressurized module, or laboratory, comes in two segments. One, called the *core segment*, contains supporting subsystems such as data processing equipment and utilities for both the pressurized modules and the pallets. It also has laboratory fixtures such as floor-mounted racks and work benches and supplies and appropriate working space. The second, called the *experiment segment*, is used to provide more working laboratory space. It contains only floor-mounted racks and benches. When only one segment is needed, the core segment is used.

Five *pallet segments*, each 3m (10 ft.) long, are available. Each pallet is not only a platform for mounting instrumentation but also can cool equipment, provide electrical power and furnish connections for commanding and acquiring data from the experiments. When only pallets are used, the essential subsystems for supporting experiments (power, communication, etc.) are protected in a small pressurized and temperature-controlled housing called an *igloo*.

The pallets are designed for large instruments, experiments requiring direct exposure to the space environment or those needing unobstructed or broad fields of view. Such equipment includes telescopes, antennas and sensors such as radiometers and radars.

Spacelab is expected to make significant contributions to science, medicine, industrial processing and many other valuable fields. In perspective, however, the most important result of this international space laboratory may well be the great step forward that it represents toward global cooperation in space. It is an outstanding example of how peoples of many lands can unite their talents and resources in future space projects to benefit humanity.



Mariner 10 photographed Mercury's northern limb in 1974

Exploring the Inner Planets (Mercury, Venus, Earth, Mars)

In the approximately 20 years of the Space Age, knowledge about the solar system has advanced farther than in all the previous centuries since civilization began. Revolutionary views of the planets have been provided, mostly by NASA Mariner, Pioneer, and Viking spacecraft and also by NASA-supported telescopic, balloon, sounding rocket and high altitude aircraft studies.

Mercury

Even the best telescopic views from Earth have shown Mercury as an indistinct blob lacking in surface detail. The planet is so close to the Sun that it is usually swallowed up in the Sun's glare. Although Mercury may be seen briefly on Earth's horizon just after sunset or before dawn, it is obscured by haze and dust in Earth's atmosphere. Radar telescopes, however, indicate a rough and possibly cratered surface.

Now, thanks to NASA's Mariner 10 spacecraft, sharp pictures of about half of Mercury's surface and much other new information about the planet are available. The pictures reveal a desolate heavily cratered surface, the scars of impacts of huge meteorites that occurred billions of years ago. In many respects, the surface resembles that of our Moon. No volcanic activity or atmospheric erosion has occurred apparently since early in Mercury's lifetime, more than 3 billion years ago.

A surface phenomenon apparently unique to Mercury also was discovered. It appears, that as Mercury's interior cooled and shrank, it compressed the planet's crust, creating huge scarps (cliffs) that crisscross the planet. The scarps are as high as two kilometers (1.2 miles) and as long as 1500 kilometers (900 miles).

Mercury, like the Earth, appears to have a crust of light silicate rock. Silicates weigh about three times as much as water. The average density of Mercury is about 5.5 that of water. To reach this kind of average density, Mercury must have a heavy iron-rich core that makes up half of its volume. In comparison, Earth's core is 25 per cent of its volume.

Mariner discovered a trace of an atmosphere on Mercury. A trillionth the density of Earth's, it is composed chiefly of argon, neon, and helium.

A surprising discovery was a Mercurian magnetic field. Scientists usually associate magnetic fields with motions of fluids in a planet's core. The motions are believed to be caused by the planet's rapid rotation.

Mercury's nearly 59-day period of rotation, amounting to a spin rate at the equator of about 10 kilometers (6 miles) per hour—Earth's spin rate is 1600 kilometers (1000 miles) per hour at the equator—can hardly be called rapid. Among other things, the existence of Mercury's magnetic field raises questions about magnetic field theories.

Mercury's magnetic field is only a hundredth the magnitude of Earth's. It can divert the solar wind (hot electrified hydrogen gas particles rushing from the Sun) but cannot capture atomic particle radiation and create an intense radiation zone like the Van Allen one around Earth. Atomic particle radiation is generated principally by the Sun and other stars. It consists of atomic nuclei, protons, and electrons.

Mariner 10 reported Mercury temperatures ranging from 510°C (950°F) on the sunlit side to −210°C (−350°F) on the dark side. The planet is literally baked by day and frozen by night.

Life on Mercury is out of the question because of the absence of water, temperature extremes, and lack of livable atmosphere.

Mariner 10 swept nearby and gathered information about Mercury three times: March 29 and September 21, 1974, and March 16, 1975. Afterwards, it literally ran out of gas—the cold nitrogen gas that was needed to orient the craft for pointing its cameras and other sensors at Mercury.

Apollo 10 photograph of earth, one-quarter million miles away.

Venus

In close-up pictures taken by Mariner 10, Venus' topmost clouds appear to circle the planet about 60 times faster than the planet rotates. The clouds look like cirrus clouds over Earth, but there the resemblance ends. NASA high altitude aircraft studies show that the topmost clouds of Venus are made up of droplets of corrosive sulphuric acid rather than water-ice particles as cirrus clouds of Earth.

Venus' atmosphere interacts with the solar wind to form an ionosphere (an electrified part of the atmosphere). Earth's ionosphere is formed by interaction of solar ultraviolet light and air molecules. The resulting Venusian ionosphere diverts most of the solar wind around Venus. In contrast, the solar wind is deflected around Earth by Earth's magnetic field.

Mariner 10 confirmed previous observations by Mariners 2 and 5 that Venus' atmosphere is about 95 per cent carbon dioxide and that Venus' surface air pressure is about 100 times Earth's.

Moreover, the thick carbon dioxide atmosphere acts like a one-way valve, admitting sunlight but trapping outgoing infrared (heat) radiation, creating what is popularly termed the "greenhouse effect." This effect is responsible for the planet's high temperature which at Venus' surface is about 450°C (900°F), hot enough to melt lead. The atmosphere appears to circulate this heat around the planet as Mariners' instruments indicate no significant difference in temperature between Venus' day and night sides.

Two Soviet Venera spacecraft landed on and reported from different regions of Venus before the spacecraft were rendered inoperable by the crushing pressures and scorching temperatures. Physical and chemical data from the spacecraft such as the lack of appreciable winds and water indicate a geomorphically inactive Venusian environment—one in which geology is relatively fixed. The pictures, however, show fractured rock and apparent downward movement of rock fragments, rounded rock edges, and pitted rock surfaces. These features would indicate a geomorphically active environment. Thus, this slight lifting of the veil from Venus has raised new questions about its surface.

Earth

From space, Earth is characterized by its blue waters and white clouds that cover a major portion of the planet. Earth is surrounded by an ocen of air consisting of 78 per cent nitrogen, 21 per cent oxygen, and 1 per cent argon, neon, and other gases. Atmospheric pressure is about 1033 grams per square centimeter (14.7 pounds per square inch) at sea level. Temperatures range from a maximum of about 60°C (140°F) in places along the equator to a minimum of 90° below zero (130° below zero F) in its polar regions. In between, temperatures are more benign. Earth spins rapidly and has a molten core, giving rise to an extensive magnetic field. The atmosphere and magnetic field shield us from nearly all of the harmful radiation coming from the Sun and other stars and the atmosphere burns up most meteors before they strike Earth.

Earth's surface shudders with lethal earthquakes and volcanic eruptions. Its atmosphere and oceans, which are hospitable to life, from time to time create destructive hurricanes and other violent windstorms, blizzards, sleet, and hail. Towering tidal waves and floods sometimes rush across the land, destroying all in their paths. Seething electrical discharges called lightning may strike deadly blows. Wastelands of deserts and ice cover significant parts of the planet. Prolonged droughts and flash floods occur from time to time.

But life is tenacious and grasping and can establish itself, despite obstacles, where the conditions for life are suitable. And Earth's conditions are and have been suitable.

Satellites have added to knowledge about and are bringing many benefits to our planet. We now know,

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Mariner 9 photographed a "River" on Mars in 1972.

through them, that Earth is surrounded by an intense radiation zone, called the Van Allen Radiation Region. We know that our magnetic field tends to arrange itself like the iron filings around a bar magnet but is distorted into a teardrop shape by the solar wind. The narrow end of Earth's magnetic field points away from the Sun. We know that the magnetic field does not fade off into space but has definite boundaries. And we know that our wispy upper atmosphere, once believed calm and quiescent, is not so at all. It seethes with activity. It swells by day and contracts by night and does the same with the rise and fall of solar activity. Its properties differ from place to place over Earth. It contributes to weather and climate.

Earth has a single Moon. The Moon's diameter is about a fourth of Earth's. NASA's Apollo expeditions have explored the Moon. As a result, we know that the Moon has had no significant volcanic activity for at least three billion years. We know what the surface of the Moon is made of, and surprisingly, it is a lot like Earth's; but the Moon has only a trace of an atmosphere and that consists of solar wind particles captured from the Sun. It has no magnetic field. It has no water, either free or chemically combined in rocks. It has no signs of life, past or present, nor even organic substances that would indicate that life processes had started but been aborted by the Moon's temperature extremes, lack of atmosphere, and absence of water. Essentially, the Moon appears to be a fossil whose study is telling us about the history of Earth, Sun, and the solar system. However, there is as yet insufficient data on which to base a determination of the Moon's origin.

Mars

Features of Mars hostile or conducive to life, as indicated by NASA's Viking spacecraft, are summarized below.

Support Life

Atmospheric components include all elements needed for life: nitrogen, carbon, oxygen, and water vapor.

The polar icecaps contain substantial quantities of water.

Summertime noon temperatures at the equator are about 27°C (80°F).

Hostile To Life

Atmospheric pressure at best is only 1 per cent of Earth's. Air so thin is found at Earth's altitude of about 32 kilometers (20 miles). Air this thin causes an animal's blood to boil.

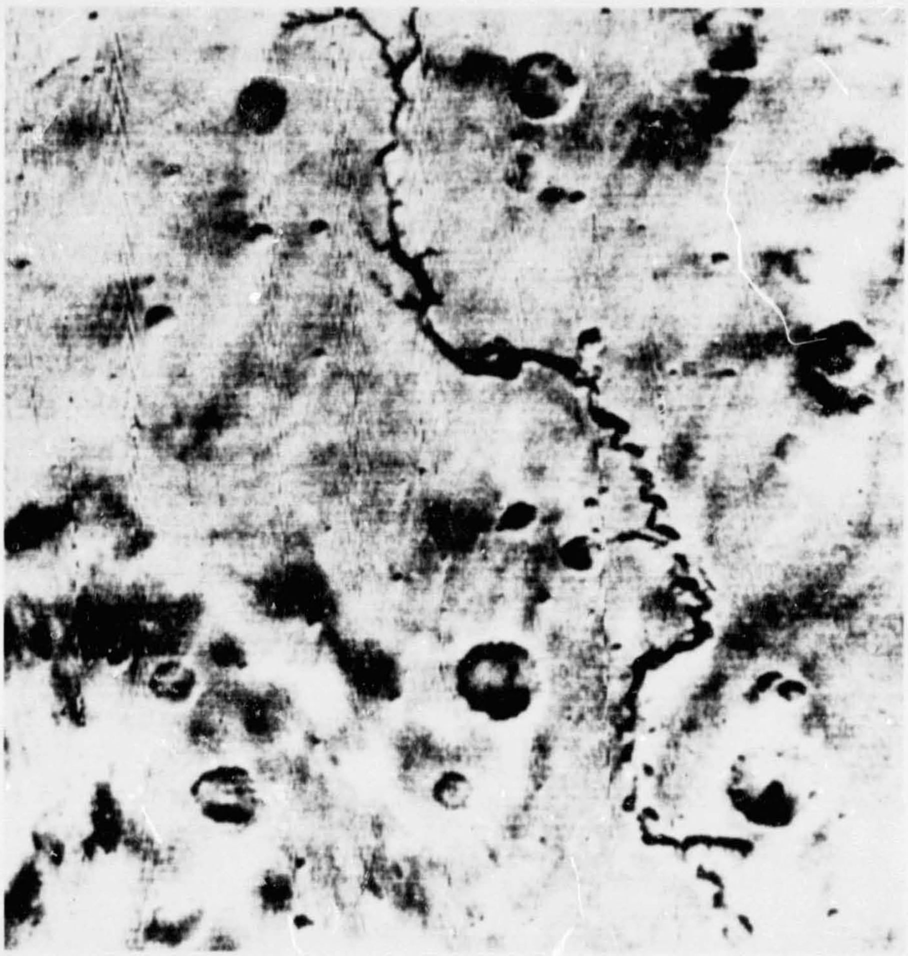
There is not enough ozone in the Martian ozone region to ward off lethal solar ultraviolet radiation. (A thick ozone layer shields life on Earth's surface from this harmful radiation).

Liquid water would vaporize instantly in Mars' thin atmosphere.

Equatorial temperature falls as low as about 100° below zero C (150° below zero F) at night.

Viking landers' soil samples exhibited chemical reactions suggesting but not necessarily proving existence of life, as these reactions could also be the result of non-living processes. Disappointing to life scientists was the absence of evidence of organic molecules, a key indicator of past or present life or that evolution toward living things has at least begun.

Viking could not crack open Martian rocks in its search for life. Back on Earth, however, scientists studying the bleak Antarctic Continent broke open rocks from Antarctica's Dry Valleys. The Dry Valleys had long been regarded as lifeless. No animal life is visible on the bare cliffs of the Valleys. Microbiological investigation of Valley soil revealed no native microbial life. When certain rocks from the Dry Valleys were broken open, however, they were found to contain microorganisms.



Part of the Great Rift valley of Mars – 1974 Mariner 9 Photo.

Other NASA laboratory and Antarctic field studies indicate that some Earth lichens, bacteria, algae, and fungi could withstand the severe Martian environment. Viking evidence indicates that this environment could have been more hospitable to life in the past. Physical features looking like shorelines, gorges, and riverbeds may mean that great rivers once flowed on Mars. Atmospheric analyses indicate that Mars atmosphere could have been at some past time 10 to 100 times as dense as today. Such an atmosphere would have permitted water to flow and possibly plants and animals to grow.

The lack of rainfall and the ubiquitous winds keep an appreciable amount of dust in the Martian air. Martian soil appears to contain a high proportion of red iron oxide. The iron-rich dust in the air gives the Martian sky a pinkish hue. The heavy concentration of iron oxide in the soil makes Mars the Red Planet.

Mars is the geologists' paradise. Among its features:

Valles Marineris, an approximately 5000-kilometer (3000-mile) long, 6.4-kilometer (4-mile) deep canyon that would stretch from east to west across the entire United States.

Olympus Mons is a volcanic mountain that rises 24 kilometers (15 miles) above the Martian plains, three times the distance from sea level to Earth's highest peak, Mount Everest. The volcano's nearly 540-kilometer (325-mile) diameter circular base is twice as wide as that which forms the main islands of the Hawaiian chain, the biggest volcanic pile on Earth.

A chaotic region about the size of Alaska it is characterized by short ridges, slumped valleys, and other irregular features that resemble the aftereffects of a quake or landslide. Nowhere on Earth is a comparable feature so vast. Could it be a result of surface collapse due to melting and escape eons ago of subsurface permafrost?

Global dust storms. Only on Mars do such storms cover the planet.

Heavily cratered areas that seem little changed in billions of years.

Close-up photos of Mars' two tiny moons, Deimos and Phobos, show them to be pockmarked with craters made by impacts of smaller bodies. Phobos appears particularly interesting for two reasons. It is extensively fractured, and some scientists believe that it is being gradually broken up by meteorite impacts and by tidal stresses as it orbits Mars.

Another reason is that it seems to resemble in some ways carbonaceous chondrite meteorites found on Earth. These meteorites contain amino acids, a group of organic compounds from which living matter is built up. Moreover, they contain a comparative abundance of water in various chemical combinations. Some scientists say that carbonaceous chondrite meteorites underwent little change from the time they coalesced out of the nebula from which our solar system formed until they entered Earth's environment.

Exploring the Outermost Planets (Saturn, Uranus, Neptune, Pluto, and ?)

Beyond Mars, the nature of the Solar System and its planets changes drastically. Distances between the planets are very much greater. For example, the distance between Jupiter and Saturn is more than eight times the distance between Earth and Mars; between Saturn and Uranus, about double that between Jupiter and Saturn. Moreover (with the exception of Pluto, which is believed to be an escaped satellite of Neptune), the outermost planets are immense in

size and extremely low in density.

The outermost planets are for the most part shrouded in mystery. NASA-supported ground, aircraft, balloon, and sounding rocket studies are aimed at advancing knowledge about these planets. NASA's Space Telescope, planned for the 1980s, and spacecraft flown to these planets can contribute significantly to such advances.

Saturn

Less than 200 years ago, Saturn orbiting nearly 1 1/2 billion kilometers (900 million miles) from the Sun, was still the farthest planet known to man. As the second largest planet in the Solar System and, until recently, the only known ringed one, it ranks high in beauty and interest.

With a mass 95.2 times and a volume 815 times that of Earth, Saturn is very low in density. In fact, Saturn's density is only 0.7 that of water.

Telescopic pictures of Saturn show faint cloud bands reminiscent of those visible on Jupiter. Spots akin to those on Jupiter have come and gone on Saturn. They were comparatively small and barely discernible. Saturn's bland appearance compared to Jupiter's could be due to either less atmospheric activity than on Jupiter or an overlaying atmospheric haze.

Hydrogen has been identified as Saturn's major atmospheric component. Trace quantities of methane, ammonia, and ethane also have been identified. Helium is believed to be present, as the outer planets are theorized to be composed of the same basic elements as the Sun.

Saturn, like Jupiter, appears to radiate more heat than it receives from the Sun. This could be left over from the primordial heat that was accumulated during planetary formation or result from gravitational contraction.

An Earth-orbiting satellite has picked up natural radio emissions believed to come from Saturn. Such emissions could mean that Saturn has a magnetic field and a field of trapped atomic particles like the Van Allen Radiation Region around Earth.

Saturn is most well known for its rings. Three can be discerned. They begin about 17,000 km (10,000 mi.) from the planet's cloud tops. The outermost ring ranges as much as 76,000 km (48,000 mi.) from the visible cloud tops. The rings appear to be made up primarily of water, ice or ice-covered silicate particles. Sizes of the ring particles are unknown but, based on observations, it is theorized that their sizes range from a centimeter to a meter.

The origin of the rings is also unknown, but it is hypothesized that they could be the remains either of a satellite that got too close to Saturn and was torn to pieces or of the cloud of dust and gas from which Saturn and its satellites were formed. The density of particles in the rings is considered great enough for the rings to pose a hazard to spacecraft.

Like Jupiter, Saturn is believed to have no solid surface. A popular conception of the planet depicts it as gradually changing inward to progressively denser layers of gaseous and then liquid hydrogen that encompass a comparatively small iron-silicate core.

Saturn has 10 known satellites. One, Titan, has gained widespread interest because of its size and the fact that it has an atmosphere. Titan is the largest satellite in the Solar System and larger than the planet Mercury. Titan has a diameter of 5800 km (3600 mi.)

The extent of Titan's atmosphere is debated by scientists. Some scientists theorize that air pressure on Titan's surface is comparable to that on Earth.

Identifiable components of Titan's atmosphere are methane, ethane, and acetylene.

Some sort of chemical reaction caused by solar radiation appears to have taken place in Titan's atmosphere, according to spectroscopic studies. One suggestion is that solar radiation, acting on methane, has produced polymers that have intensified a greenhouse effect on Titan. This could mean, according to the theorists, that Titan has accumulated enough heat from the meager sunlight reaching it over the past few billion years to warm its air and surface. Thus, conditions on Titan might be favorable for development of pre-life organic compounds or primitive life forms.

The theory for the favorable temperature on Titan assumes that the atmosphere lets sunlight reach the surface but restricts the passage of heat radiation from the warmed surface into space. In effect, heat radiating from Titan has been trapped, causing the temperature to rise on Titan's surface and in its lower atmosphere.

Uranus

Uranus was discovered less than 200 years ago. Like Jupiter and Saturn, the principal constituents of Uranus are thought to be hydrogen and helium. Methane has been observed in its atmosphere, which is very clear and deep. No distinctive atmospheric markings such as in the Jovian and Saturnian atmospheres can be discerned.

The structure theorized for Uranus is a core of rock and metal surrounded by layers of ice, liquid hydrogen, and gaseous hydrogen in the order named. There is no clear boundary between the liquid and gaseous hydrogen layers. Instead, as the hydrogen becomes progressively less dense with increasing distance from the core, it tends to change from a liquid to a gas. This theory about the structure of Uranus is derived from the hypothesis that the planets were initially formed by accretion of rocky and metallic material and ice around which gases accumulated.

Uranus has nine faint rings. The discovery of rings around Uranus by a NASA airborne observatory in 1977 is considered the first major Solar System structure to be found since Pluto in 1930.

Uranus' rings circle the planet at altitudes from about 18,000 to 25,000 km (11,000 to 15,400 mi.) above Uranus' visible cloud tops.

Neptune

Orbiting more than 1 1/2 billion km (900 million mi.) out in space than Uranus, Neptune was discovered less than 150 years ago. Neptune is somewhat smaller but more massive and much denser than Uranus.

Neptune, like Uranus, has a very deep atmosphere. Methane has been detected in this atmosphere. Hydrogen and helium are believed to be the planet's principal constituents.

The popular model of Neptune is like that of Uranus. Inward from its thin outer atmosphere, Neptune is made up of progressively denser lay-

Voyager I collage of Jupiter and its four planet-sized moons. Jupiter at rear; Io, top left; Ganymede, lower left; Europa, center; Callistro, lower right. 1979 photo.

ers of gases and then liquids, principally hydrogen, that surround a layer of ice and an iron-silicate core.

Neptune has two known satellites. One of them, Triton, seems to be orbiting so close to Neptune that it appears in danger of being torn apart by Neptune's gravity.

Pluto

Nearly a half century after its discovery, Pluto, which orbits as far as nearly 6.4 billion km (4 billion mi.) from Earth, continues to be a mystery. At the present time, it has looped inside of Neptune's orbit and by 1989 will be a little more than 4 billion km (2 1/2 billion mi.) from Earth, its closest distance in about 250 years.

A moon recently was discovered circling Pluto. This means that of the nine planets, only Mercury and Venus, the two nearest the Sun, do not have natural satellites.

The estimate of Pluto's size has been based upon reflection of sunlight from a supposedly silicate surface. This estimate gives Pluto a mean equatorial diameter of about 6400 km (approximately 4000 mi.), or roughly half of Earth's. A recent NASA-supported observational study of Pluto indicates that Pluto is covered with methane ice. Methane ice reflects light much better than silicates.

Considering the covering of methane ice, experimenters calculated that Pluto's diameter could be less than our Moon's which is about 3475 km (roughly 2160 mi.).

An implication with even more interest is the recalculation of Pluto's mass, considering that the methane-ice-covered surface appears to be that expected for a low temperature condensate in the outer solar nebula. Scientists report that Pluto's composition could be dominated, like most outer planet satellites, by frozen volatiles (methane, ammonia, and other light gases). If this is so, they calculate its mass at a few thousandths rather than about 0.11 of Earth's as currently estimated.

The Tenth Planet?

The recalculated mass of Pluto, scientists say, would be too little to perturb measurably the motions of Uranus and Neptune, perturbations which led astronomers to search for and find Pluto. This means that other influences were responsible for these deviations. *Could there be a massive planet far beyond Pluto? Such a body has been theorized by some scientists but never detected.*

No massive body but a comparatively small object orbiting the Sun recently was discovered under a NASA-supported observatory program. The object, named Chiron by its discoverer, is in an orbit between Uranus and Saturn. Based on its brightness and probable composition, the diameter of the object has been estimated at no more than about 640 km (400 mi.). The object does not appear to be a comet or satellite. It may be part of an undiscovered second asteroid belt. The object is so small and so far away that it will take some time before it can be more clearly identified.

Supportive Organizations

Among NASA's supportive organizations—some student oriented—with an interest in the future of aeronautics and space exploration are:

American Institute of Aeronautics and Astronautics
1290 Avenue of the Americas
New York, NY 10019

The American Society for Aerospace Education
Suite 432
821 15th Street, NW
Washington, DC 20005
(Publishes monthly September through May *Journal of Aero-Space Education*)

Aerospace Industries Association
1725 De Sales Street, NW
Washington, DC 20036

National Space Institute
Suite 408
1911 Ft. Myer Drive
Arlington, VA 22209

American Association for the Advancement of Science (AAAS)
1515 Massachusetts Ave., NW
Washington, DC 20005

Forum for the Advancement of Students in Science and Technology, Inc. (FASST)
2039 M Street, NW
Washington, DC 20036
(FASST works with both technical and non-technical students to demonstrate available technical options, and the social implications involved in science issues). FASST is an AAAS affiliate.

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Inventions

Ideas, designs, inventions and related data should be directed to:

NASA Inventions and Contributions Board
NB-9/NASA Headquarters
Washington, DC 20546

Designs must be to scale, in pen and ink and accompanied by complete technical description in order to be processed.

Sources of Information

Reading Room
NASA Headquarters Information Center, 600 Independence Avenue, SW, Washington, DC 20546. Phone: 202/755-2320.

Contract and Small Business Information
Inquiries regarding contracting or small business opportunities with NASA should be directed to the NASA Small Business Advisor and Industry Assistance Officer, NASA Headquarters, HB-1/Office of Procurement, Washington, DC 20546. Phone: 202/755-2288.

Speakers, Films, Publications and Exhibit Services

Several publications concerning these services can be obtained by contacting the Public Affairs Officer of the nearest NASA installation. Publications include NASA Film List and NASA Educational Publications List. NASA Headquarters telephone directory, certain NASA publications, and NASA picture sets are available for sale from the Superintendent of Documents, Government Printing Office, Washington, DC 20402. Telephone directories for NASA field installations are available only from the installations. NASA publications and documents not available for sale from the Superintendent of Documents or the National Technical Information Service (Springfield, VA 22151), may be obtained from NASA installation Information Centers in accordance with the NASA regulation concerning freedom of information (14 CFR 1206).

How to Obtain Official NASA Photographs

Official NASA photographs are distributed free only to the news media. They are available, however, for purchase from NASA's contract laboratories, Bara Photographs, Inc., P.O. Box 486, Bladensburg, MD 20710 or AB Service Corporation, P.O. Box 58425, Houston, TX 77058. A catalog of available photos may be obtained by writing either Bara, AB or LFB-10/Audiovisual Services Branch, NASA Headquarters, Washington, DC 20546. Both color and black-and-white material is available.

Radio and TV stations *Only* may write for NASA tape and film spots and features to Joseph L. Headlee, LFB/8, NASA Hq., Washington, DC 20546.

Souvenirs, Models, Mission Patches, Maps, NASA-Related Novelties

These items may be obtained at many commercial outlets (hobby/novelty/specialty); NASA does not, for budgetary reasons, distribute them. They may be purchased at NASA Employee Stores at the agency's principal centers (see listing of centers) by writing for price lists. A wide selection is stocked by the Gift Shop of the National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.

Possible sources for items not available free from NASA are:*

Scientific and Technical Information (Mission-Technical Reports):
National Technical Information Service, Port Royal Road, Springfield, VA 22151.

Spacecraft Models:
(Sold in model and hobby shops, specialty stores)
Revell, Inc., 4288 Glencoe Avenue, Venice, CA 90291
Precise Models, Inc., Elyria, OH 40035
Centuri Engineering Co., 3053 West Fairmont, Phoenix, AZ 85017
Estes Industries, Inc., Penrose, CO 81240
Gift Shop, National Air & Space Museum, SI, Washington, DC 20560

Emblems, Patches, Etc.:
Space Photos, 2608 Sunset Boulevard, Houston, TX 77005
Space Age Enterprises, P.O. Box 58127, Houston, TX 77058
National Medallion Company, Inc., P.O. Box 58127, Houston, TX 77058
Visitor Information Center, Johnson Space Center, Houston, TX 77058
NASA Tours, TWA-810, Kennedy Space Center, FL 32899
Communications Association Corp., 250 Babcock Street, Melbourne, FL 32925
Gift Shop, National Air & Space Museum, SI, Washington, D.C. 20560

Stamps:
Houston Philatelic Society, P.O. Box 52880, Houston, TX 77052
JSC Stamp Club, P.O. Box 58328, Houston, TX 77058

Gift Shop, National Air & Space Museum, SI, Washington, DC 20560

Moon Maps:
Superientendent of Documents, U.S. Government Printing Office, Washington, DC 20402

Planetary Data:
Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138

8mm Movies:
Joe Bonica, Movie Newsreels, 1621 Cahuenga Boulevard, Hollywood, CA 90028
National Audio Visual Record Center, National Archives Record Center, Washington, DC 20409

Space Type Foods:
Rich-Moor Corp., 616 North Robertson, Los Angeles, CA 90069
Oregon Freeze-Dry Foods, Inc., P.O. Box 666, Albany, OR 97321
G. Armanino & Sons, Inc., 1970 Carroll Avenue, San Francisco, CA 94124
Sam-Andy, Mini-Moisture Foods, P.O. Box 2125, Beaumont, CA 92223
Epicure Foods, Inc., 480 U.S. Route 46, South Hackensack, NJ 07606

Commemorative Medals:
L. G. Balfour & Company, P.O. Box 718, Attleboro, MA 02703
Space Age Enterprises, P.O. Box 58127, Houston, TX 77058

Solar System Information, Planetary Locations, Charts, Etc.:
Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138
The Hansen Planetarium, 15 South State Street, Salt Lake City, UT 84111
The Planetarium Director, Houston Museum of Natural Science, Hermann Park, Houston, TX 77002

*Note: This list is furnished as a service only. It does not imply that NASA endorses these sources. Also, there may be other outlets that offer similar products or services.

Why Explore Space? Answers to Other Often-Asked Questions

The exploration of space is producing practical benefits in the form of:

Knowledge—Exploration advances scientific and technical knowledge and thus contributes to understanding and improving life on Earth.

Applications—Spacecraft are already in constant service for communications, navigation, weather observations, and Earth environmental surveys.

Technology—progress stimulated by the space program is contributing to advances in medicine, transportation, electronics, manufacturing, and nearly every other form of human activity.

Economics—The space program helps expand our technological base, stimulating the development of improved products and processes that increase our ability to compete in world markets. In this way, the program makes a significant contribution to the export, or plus, side of our balance of trade.

What does the Space Program cost me as an individual?

About one cent of each Federal tax dollar goes to the space program.

Why not use some of the money spent on space to solve social problems such as hunger, poverty, ill health, and pollution?

The Federal Government is already spending over $100 billion a year on social programs, including those to alleviate poverty, improve health, control pollution and eliminate hunger. This is over 40 per cent of the national budget. In contrast, actual spending for space accounts for less than 2 per cent of the budget. To divert funds from the space program would not add significantly to the budget for social programs, but it would be a severe blow to the advances in technology, the growth of knowledge, the economic advantages, and the practical benefits produced by the space program.

Can I obtain actual spacecraft items from NASA?

No. Hardware and other items no longer of operational use usually go to public institutions or museums for display so that the maximum number of people may see them. Flight plans, designs, transcripts and printed materials are prepared in limited quantity for distribution only to analysts, investigators, engineers and other personnel on a need-to-know basis.

How much does a spacecraft weigh in space?

A spacecraft in orbit around Earth is said to be in a state of weightlessness, also called zero-gravity or zero-g. Weightlessness does not mean that the gravity of Earth has disappeared or that the spacecraft and its contents do not have mass. Rather, it means that the "weightless" spacecraft is subject not only to gravity but also to the velocity imparted by its launch vehicle, which balances the force of gravity. This produces apparent lack of gravitational pull, hence, zero-g. Put another way, gravity and the motion of the spacecraft interact to hold the spacecraft in orbit where it is weightless. The spacecraft's movement may be described as falling toward Earth but with the curved surface of Earth falling away from its path so that it continues to fall around Earth. Everything in the spacecraft is also weightless, as is anything which separates from it. The weightless condition also applies to spacecraft on long journeys between planets because they are effectively falling freely in the gravitational field of the Sun.

How hot or cold does it get in space?

In space around Earth, including the vicinity of the Moon, objects in sunlight heat up to about 121° C (250° F); when shielded from the Sun, objects cool to as low as minus 156° C (minus 250° F). Astronauts in protective suits or in a spacecraft cabin experience a steady 21° to 27° C (70-80° F) as long as thermal control systems are working properly.

How does the Space Shuttle space suit differ from previous models?

The Shuttle backpack life support system is far less bulky and more comfortable. It is also more versatile and easier to manage. In previous programs, an entirely new space suit was worn on each flight and was custom-tailored to fit each astronaut. But Shuttle suits will come in standard pieces which can combine to fit either male or female crew members of different sizes. Because these pieces may be repaired and reused for six years or more, it will cost much less to outfit our astronauts.

How were NASA program names (Mercury, Gemini, Voyager, Viking, Apollo) chosen?

Officials considered various suggested names and finally agreed on one. Sometimes the names were descriptive, such as Skylab and Space Shuttle. Gemini—Latin for twins—referred to the fact that the Gemini spacecraft held two astronauts. Names such as Mercury and Apollo were much more symbolic than descriptive.

Aeronautical Research At NASA

Quiet, comfortable, convenient, safe, and economical air transportation in a time of steadily rising costs and growing fuel scarcities are some of the vital challenges that NASA programs in aeronautics are helping to meet.

Meeting today's challenges continues more than 60 years of NASA aeronautical research—research that has contributed significantly to United States world leadership in the development and sale of civil and military aircraft.

Through research, wind tunnel simulations, and experimental flight programs, NASA scientists, engineers, and test pilots work closely with U.S. industry, universities, and other government agencies. Programs and projects span the atmospheric flight spectrum from hovering to hypersonic flight and from sea level to the stratosphere.

New designs, materials and technology are pointing the way toward major reductions in aircraft noise and airport congestion. Other scientific approaches probe the high-speed end of the flight regime, developing the means to economically fly faster and smoother.

Noise Abatement

Research on jet engines is helping to decrease substantially the noise levels of aircraft to make them better neighbors so that aircraft can use airports near cities and residential communities. Door-to-door travel time for passengers can thus be shortened significantly.

NASA is also experimenting with steeper and curved landing approaches which keep aircraft higher over populated areas, thus lessening the noise that reaches airport communities.

V/STOL Research

Other NASA efforts are paving the way for development of safe, clean, quiet, and efficient jet V/STOL (vertical and short takeoff and landing) aircraft for commercial airline service. V/STOL airplanes, requiring short runways (or none at all), could reduce substantially the congestion and delays at major U.S. airports and the need for additional large jetports. The shift to V/STOL operations would also permit fuller utilization of the present large metropolitan jetports for transcontinental and transoceanic airliners.

Smaller, less-congested V/STOL airports could be developed for inter-city flights of less than 500 miles which now account for about 80 percent of all air travel and are expected to about triple in another decade. V/STOL "Quietports" could be designed into community town areas, providing a welcome convenience for air travelers by reducing their travel time to and from major airports.

NASA is conducting wind tunnel tests, noise reduction studies, powerplant development, and flight operations research for promising V/STOL aircraft concepts.

Among the purely VTOL (vertical takeoff and landing) research projects is a joint NASA-Army Rotor Systems Research Aircraft. NASA is developing VTOL technology to increase helicopter performance, safety, reliability, and strength and to reduce noise, maintenance requirements, and vibrations.

A NASA flight program with a large helicopter (CH-53) demonstrates the use of current technology in reducing passenger compartment noise and vibration levels to facilitate civil application of helicopters in feeder line transportation.

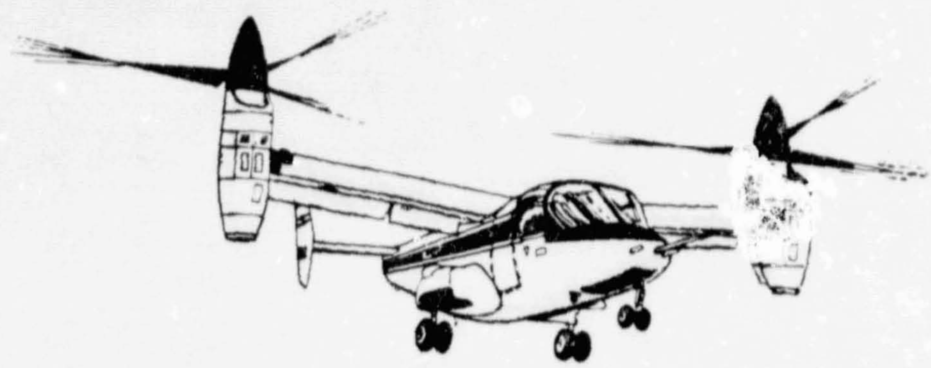
NASA research engineers and pilots have achieved the first fully automatic landings at a predetermined spot by a full-scale manned helicopter. The landings were conducted to study performance requirements for automatic VTOL aircraft operations in all-weather city-center to city-center service.

This continuing research is aimed at enabling helicopters and other future VTOL aircraft to fly routine missions under poor visibility conditions.

There have been a number of NASA studies on combining into one craft the crusing characteristics of the conventional airplane and the vertical lift and landing features of the helicopter.

NASA is flight testing a tilt-rotor research aircraft in a joint NASA/U.S. Army "proof-of-concept" flight research program. This tilt-rotor concept uses large rotors mounted at the wing tips for vertical takeoff and landing life a helicopter. Once airborne, the rotors tilt forward to provide cruise propulsion like conventional turboprop airplanes. The longer ranges and higher speeds than helicopters, combined with the utility of helicopters, show considerable promise.

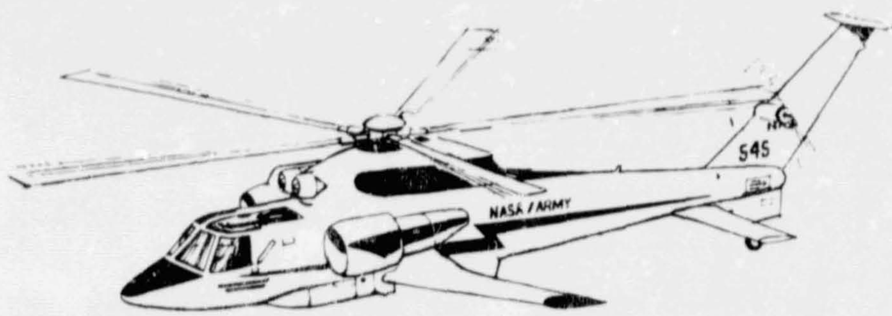
In STOL research, NASA is experimenting with propulsive-lift concepts whereby a jet engine's exhaust is used to add to the lift normally provided by airflow over the aircraft wings and flaps. Higher lift is a key to slower takeoffs and landings and the use of shorter runways at smaller, more conveniently located airports. The slower terminal-area flight speeds also enhance safety and may permit bad weather flight minimums to be safely lowered.



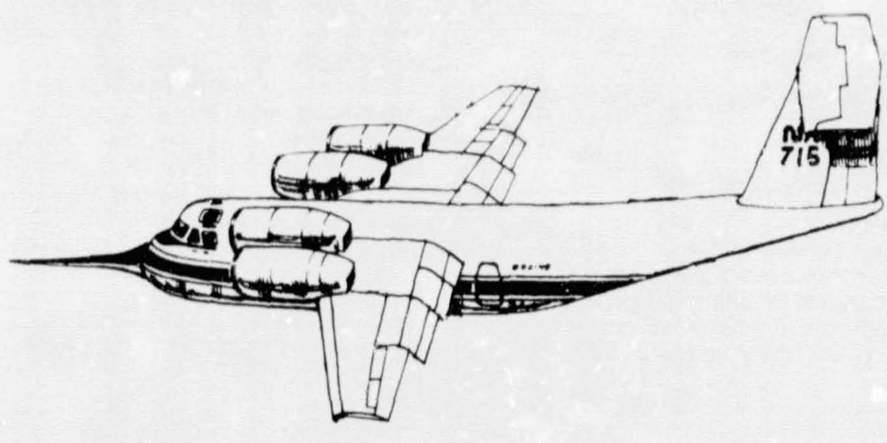
Tilt Rotor

An important NASA goal is to make STOL aircraft good neighbors, environmentally acceptable, while providing convenience to air travelers. This program is developing new quiet, clean, short-haul engine technology for STOL aircraft. (Short haul refers to 500 miles or less.)

The Quiet Short-haul Research Aircraft (QSRA) of NASA is validating quiet, propulsive-lift technology in a flight research program. The lift capability of the QSRA is about three times greater than any jet transport in commercial operation today, while its noise is only a small fraction of what current aircraft generate.



Rotor Systems



Quiet Short-haul

Energy Efficiency

Fuel costs account for some 20 percent of the total operating expenses of airlines. As fuel prices climb, aircraft energy efficiency—fuel economy—takes on increasing importance.

NASA has identified technologies that in coming years could cut fuel consumption of civil air transports in half. Based on estimates of the size of the domestic commercial air fleet in 2005, these technologies could save about a million barrels of fuel daily, helping to conserve dwindling supplies of petroleum and to reduce reliance on foreign oil. Development of such fuel-efficient air transports will be of equal importance to foreign airlines, a big market for American-built aircraft.

Broad-scale engine tests are conducted by NASA to determine why certain engine components deteriorate and which impaired components waste the most fuel. The objective is to have improved components available by 1980 that could decrease engine specific fuel consumption by 5 percent. (Specific fuel consumption refers to the amount of fuel used by a jet engine to produce a pound of thrust. As specific fuel consumption drops, mileage climbs.)

A number of advanced fuel-saving engine concepts are being examined. Engines employing advanced technology are expected to be available for new aircraft brought into service by 1990. A 10-percent decrease in specific fuel consumption is estimated as a result of such improved engines.

The application of NASA advanced aerodynamic design and electrical control systems to aircraft could reduce fuel consumption by 15 to 20 percent. For example, flight tests of the NASA supercritical wing have indicated that it can increase the range of aircraft by some 15 percent.

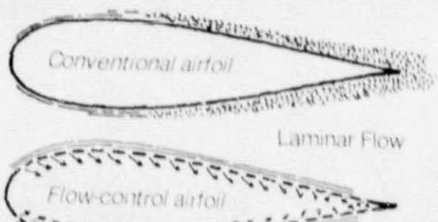
Another aerodynamic innovation consists of nearly vertical airfoils, called winglets, at the wingtips. The winglets act both as lifting surfaces and to reduce air drag.

Substantial additional fuel savings are available through development of controls technology. NASA has made significant progress with its fast-acting computer-coordinated flight control system called digital fly-by-wire. The rapid response of the system can significantly increase aircraft stability and damping which in turn reduces structural loads and aircraft weight.

One problem of traveling at high speeds occurs in the boundary layer, the thin sheet of air that flows along the surfaces of the wing, fuselage, and tail of an airplane. The boundary layer changes from laminar (smooth) to turbulent, creating friction and drag that waste fuel.

Laminar flow control provides the greatest potential for fuel conservation but would require some radical changes in aircraft design. Estimates of fuel savings range from 20 to 40 percent, depending on the extent of application and the airplane's design range.

The laminar flow control concept calls for removing the turbulent boundary layer by sucking some of the air inside through many tiny apertures and thus maintaining smooth flow across and around the aircraft's surface.



Laminar Flow

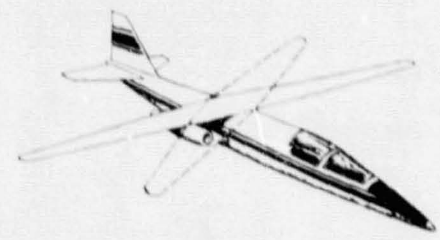
Using composite materials rather than metal alone can decrease aircraft structural weight by about 25 percent reducing fuel consumption by 10 to 15 percent. Many composite materials are not only lighter but stronger. NASA research activities will provide design and manufacturing data and will demonstrate the durability of composite materials in a flight evaluation program. (Composites consist of filaments of boron or graphite arrayed in an epoxy, polymide, or aluminum matrix.)

Modern high-speed turboprops have the potential for 20 percent fuel savings, compared to modern turbofan engines. NASA is developing the technology to demonstrate that future aircraft powered by advanced turboprops will be comfortable, quiet, fast, and economical to operate.

High Performance

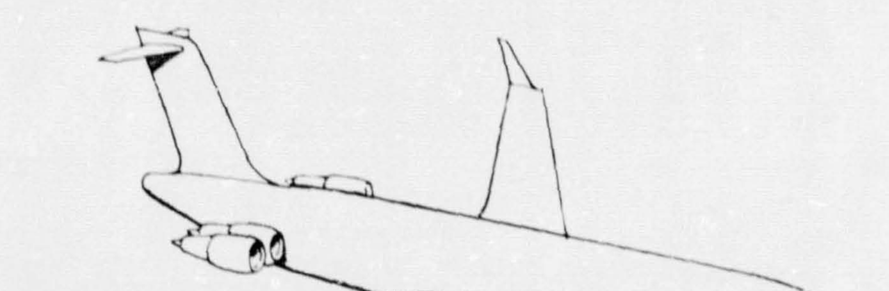
NASA studies and research are addressing the technology needs of both supersonic and hypersonic cruise flight for potential military and civil applications. Other studies address future, large cargo concepts and lighter-than-air vehicles.

One design innovation is the antisymmetrical wing. This wing crosses the airplane's fuselage at a right angle for takeoff and landing and pivots to cross the body diagonally for high speed flight. Preliminary studies indicate the wing would enable an airplane to operate more quietly and use less fuel than current delta-wing jets during take off and landing and at cruising altitudes of 40,000 feet. At supersonic speeds up to Mach 1.2, an antisymmetrically-winged plane would not produce a sonic boom on the ground.



Cargo Concept

An unmanned, supersonic research aircraft, called HiMAT for Highly Maneuverable Aircraft Technology, will preview the performance of future fighter planes in transonic maneuvers. Tests with this radio-controlled NASA/U.S. Air Force research aircraft will enable U.S. fighters of the 1980s and 1990s to substantially outperform today's most modern "dog-fighting" aircraft.



Aircraft Operations

The NASA Terminal Configured Vehicle and Avionics Program uses a Boeing 737 aircraft in research on present and future airport environments. The program is studying more efficient and quieter air paths in and out of airport terminal areas and is investigating aircraft performance requirements, automatic systems, and displays to minimize pilot workloads in airport areas. The program is part of the efforts to provide better public transportation services by solving such problems as aircraft noise, airway and airport congestion, and the lack of all-weather operations capabilities.

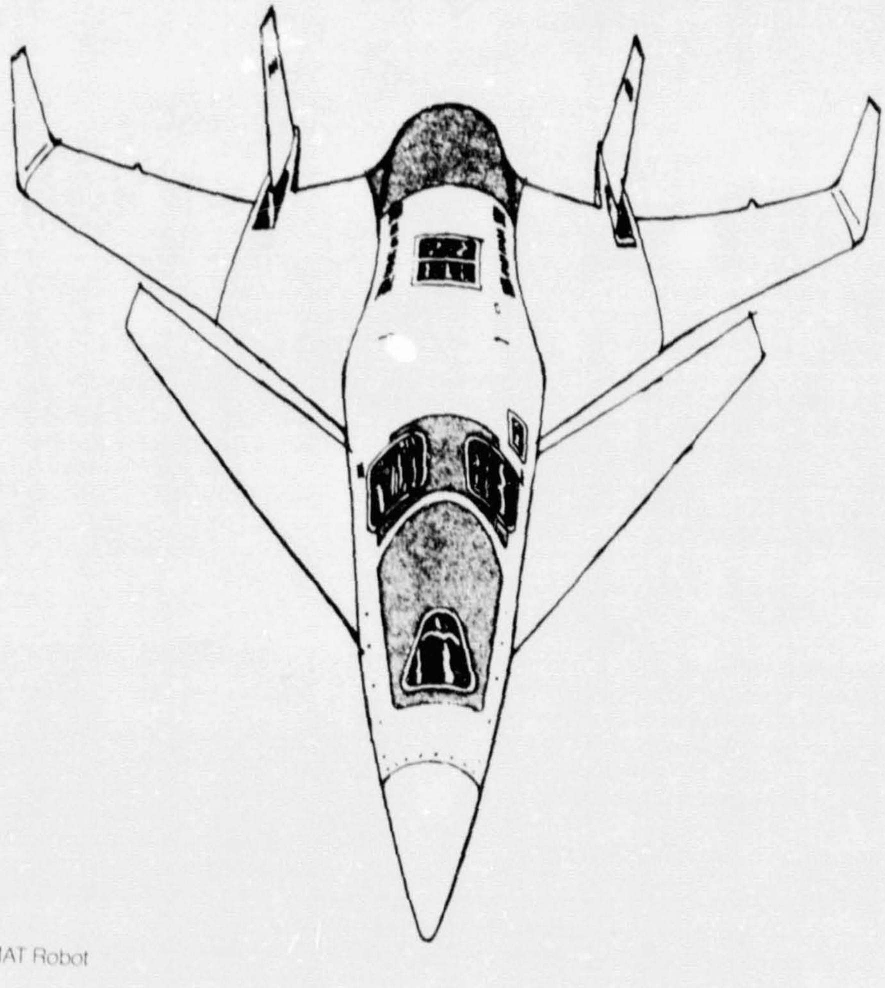
NASA scientists are investigating systems to warn pilots of two invisible menaces: clear air turbulence and trailing vortices (spiralling winds that trail, often a mile or more, from the wingtips of aircraft). All types of aircraft generate trailing vortices, but heavier aircraft produce the strongest ones.

For the present, the FAA requires a 5-mile spacing between large and small aircraft approaching terminals for landings. The spacing allows time for crosswinds to break up the trailing vortices but it also slows flight operations and contributes to passenger delays caused by airport congestion. NASA, through wind tunnel and other experimental techniques, is investigating concepts to reduce the strength of the wake vortices which would allow closer aircraft spacing to take place and reduce delays.

Clear air turbulence is caused by naturally occurring tempestuous air currents. These can unexpectedly add bumps to an aircraft's and passenger's ride even though the sky is cloudless. NASA is testing systems that detect clear air turbulence ahead of the aircraft. With such early warning, airline pilots can avoid the turbulence.

General Aviation

Objectives of the NASA General Aviation Research and Technology program include providing new technology for improvements in safety and efficiency; reduced environmental impact; and to insure generally that an adequate base of new technology will support continued growth in the utility of light airplanes. These efforts encompass research in aerodynamics, propulsion, avionics, traffic advisory systems, crashworthiness, noise abatement, emission reduction, and stall/spin prevention.



HIMAT Robot

In these and many other activities, NASA continues to improve air transportation for the benefit of the traveler, shipper, operator, and others whose lives are affected by the airplane.

NASA House Organ

"NASA Activities," published monthly at NASA Headquarters for its employees agency-wide, is for sale to the public by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, at an annual subscription rate of $11.55, domestic, $14.45, foreign. Price per single copy is $1., domestic, $1.25, foreign; back issues are not available.

NASA Mailing Lists

For budgetary reasons, the only regular mailing lists maintained by NASA are for news media which have requested they be sent NASA material and regular mailings to educators.

Naming Of Astronomical Features

By international agreement, the naming of lunar and planetary features is the responsibility of the International Astronomical Union, 21 Beneluxaan, Utrecht, The Netherlands. Proposals for name changes should be submitted to IAU.

Miscellaneous

Unidentified Flying Objects

NASA's relationship to UFOs is to place under laboratory analysis and report on any *physical* evidence of their existence submitted from credible sources. NASA has no pictures, files or sighting reports and is not conducting a continuing UFO investigation. A number of private groups devote full time to aerial phenomena research.

Two of them are: The Center for UFO Studies, 1609 Sherman Avenue, Evanston, IL 60201, Dr. J. Allen Hynek, director; and National Investigations Committee on Aerial Phenomena (NICAP), 5102 Del Ray Avenue, Washington, DC 20014, Alan N. Hall, director.

Congressional Space Medal of Honor

On September 22, 1978, six astronauts were awarded the Congressional Space Medal of Honor, the first such medal awarded by the United States. The recipients were Neil A. Armstrong, Frank Borman, Charles Conrad, Jr., John H. Glenn, Jr., Alan B. Shepard, Jr., and Virgil I. Grissom (posthumous). Authorized by Congress in 1969, the award is given to "any astronaut who in the performance of his duties has distinguished himself by exceptionally meritorious efforts and contributions to the welfare of the Nation and of mankind." Presentation of the medals by President Carter was at Kennedy Space Center, FL, Oct. 1, 1978, 20th anniversary of the founding of NASA.

The Bermuda Triangle

NASA Aircraft and satellites have photographed this general area of the Atlantic Ocean; however, the agency has not been assigned the task of investigating. Information on the subject may be obtained from: Chief of Information, OIN/Office of the Chief of Naval Operations, The Pentagon, Washington, DC 20310.

The Shroud of Turin

NASA has not been directly involved in research on the Turin shroud. For information on Jet Propulsion Laboratory participation in studies of the artifact, please address inquiries to: Public Affairs Officer, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91103.

Cape Kennedy Name Change

Shortly after President Kennedy's assassination in 1963, the names of both the land body (Cape Canaveral) and the NASA installation were changed to Cape Kennedy and NASA John F. Kennedy Space Center, respectively. Floridians, stating they meant no disrespect to the memory of the fallen President, felt the Cape's original name should be restored—the name it was given by the Spanish explorers who discovered it in 1513. The Florida legislature made the change official May 29, 1973, and the U.S. Interior Department's Board of Geographic Names took the same action the following October. NASA's Kennedy Space Center is not located on Cape Canaveral (which is part of the USAF Eastern Test Range) but on nearby Merritt Island.

Satellites and Weather Conditions

There is no evidence to support a belief held by some that satellites affect weather conditions on Earth.

Ownership of the Moon

By international agreement the lunar surface is considered to be the property of all mankind, not of any one nation. Thus, it is not possible for individuals to lease or purchase acreage for private use through their own or other governments.

The treaty, which binds the United States and over 50 other countries, provides that, "Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

This country has on six occasions placed its flag on the lunar surface. This act was intended as a symbolic gesture of national pride in achievement and not as a claim of sovereignty.

Lost Day in Time

There is no truth to the recurring story that NASA uncovered a "lost day" in the movement of the Earth. Although planetary positions are used to help determine spacecraft orbits, we have been unable to learn of any computations in the space program which revealed a "lost day" as has been reported in a number of places.

Memorial to Deceased Spacemen

A memorial to 14 deceased American and Soviet spacemen was placed on the Moon in August 1971. The memorial consisted of a plaque and a small figure representing a fallen astronaut. Names of Americans and Russians, listed on the plaque alaphabetically, were:

Charles Bassett
Pauel Belyayev
Roger Chaffee
Georgiy Dobrovolskiy
Theodore Freeman
Yuri Gagarin
Edward Givens
Virgil Grissom
Vladimir Komarov
Viktor Patsyev
Elliot See
Vladislav Volkov
Edward White
Clifton Williams

Astronaut David R. Scott, who placed the memorial on the Moon during the Apollo 15 mission, remarked: "Many people have contributed to this pinnacle we've reached and we know of 14 individuals who contributed all they had."

Safeguarding of Satellites

All NASA satellites carrying nuclear material are designed for reentry without the release of radioactive matter. Only one, Nimbus 3, launched in 1969, is still in orbit where it is expected to remain indefinitely.

Nimbus 2 aborted at launch and its Plutonium-238 package was recovered; Pioneers 6 and 7 and Voyagers 1 and 2 will leave the solar system; Apollos 12 and 14 through 17 left nuclear packages on the lunar surface; Vikings 1 and 2 placed packages on Mars and the intact Apollo 13 Plutonium container sank several thousand feet in the Pacific Ocean.

Transfers of Aerospace Technology

Aerospace technology is accomplishing things that otherwise could not be done economically—or perhaps not done at all. This is occurring in global communications, navigation, oceanography, meteorology, geology, astronomy and, of course, exploration of the solar system.

At the same time, the pursuit of aerospace goals generates innovations in

virtually all fields of science and technology. Such innovations help stimulate progress in many areas that often are not even remotely related to the original projects.

So thoroughly have aerospace technology transfers pervaded our lives that the many benefits attributable to the stimulus of the space program are difficult to measure in their entirety. However, an economic study recently traced the spinoffs from four NASA projects in order to evaluate the benefits to the national economy from secondary applications of aerospace technology. This study estimated that the secondary benefits in these four areas alone will return almost $7 billion to the economy by the early 1980s. Results of the study are summarized below.

Integrated circuits.
Developed for satellites, communications and other space uses. Now used in TV sets, automobiles and hundreds of industrial and household products. It is estimated that the improved technology will return over $5 billion from 1963 to 1982.

Insulation for cryogenic uses.
The cryogenics (ultra-low temperature) industry erupted as a direct result of liquid gases needed for rocket propulsion and life support in space. Today hospitals and steel mills are among dozens of beneficiaries that store and use liquid oxygen, nitrogen, helium and other frozen gases. Estimated benefits: over $1 billion by 1983.

Structural analysis computer program.
Developed originally to help design more efficient space vehicles, this NASA program today is used to help design railroad tracks and cars, automobiles, bridges, skyscrapers and other structures. Use of the program yields about a 60 percent improvement in predicting the behavior of stressed parts and a two-thirds cut in calculation time. The program is expected to return more than $700 million in cost savings from 1971 to 1984.

Gas turbines.
Initially developed for jet-engine aircraft, but widely spun off to electric-power generation plants, these turbines will effect low-cost savings of an estimated $111 million between 1969 and 1982.

Some of the thousands of transfers of aerospace technology are listed below:

Health Services/Rehabilitation

- Rechargeable Heart Pacemakers using nickel-cadmium battery technology
- Composite materials used for lightweight limb braces
- Open-celled polyurethane-silicone plastic foam
- Mobile automated metabolic analyzer used to measure energy expended by orthotic-equipped patients
- Mercury-zinc battery technology used for heart Pacemaker
- Artificial hand with trigger finger
- Control switch operated by eye movement—allows paralyzed patient to control TV set, book page turner, bed position, lights, etc.
- Hand physiotherapy device
- Electromechanical simulator modules
- Horizontal shower used for bedridden patients
- Portable laminar airflow surgical clean room
- Heat pipe applications used for treating hemorrhoids, malignant tumors, and cervicitis
- Paper money identifier for the blind
- Toxicological effects of polyvinyl chloride (PVC) plasticizers
- Cardiac care systems for emergency rescue vehicles

Environmental Quality

- Carbon monoxide monitor—commercialized as air pollution monitor
- Hazardous gas analyzer—adapted for use on automobiles
- Coal desulfurization process—adapted from Lunar Module rocket engine test facility
- Contamination prevention handbook—used by compressor manufacturers for inhouse pollution control
- Remote sensing of air pollutants used worldwide
- Computerized image enhancement used to measure quality of water in inland lakes and streams
- Fan noise reduction method—used to design inexpensive acoustic panels
- Apollo Program Quality Assurance Specifications—offered by General Electric as part of consulting services for utilities seeking nuclear power plant licenses
- Pyrolytic synthesis of activated carbon used to increase raw sewage settling rates by 100-fold in Orange City, California pilot plant
- Satellite photos used for making more accurate maps of remote areas such as swamp lands

Petroleum and Gas

- Heat pipe technology developed for Skylab, Space Shuttle, and unmanned satellites—used in the construction of the Alaskan Pipeline
- Infrared scanner and television display—used for maintenance inspections at petrochemical plants and refineries
- Hot tapping method for pipes—used by American Oil Co. to repair pipes and valve leaks
- Multiplexer circuit for Saturn rocket—used for remote data acquisition and control systems for oil and gas pipelines and oil field production equipment
- Apollo Guidance Computer Software—adapted for use in control systems for oil field production and oil and gas pipelines. Used by over 30 major oil and gas companies
- Reliability and quality assurance methods—basis for improved assurance by federal government and industry that offshore oil and gas will be produced safely and with minimal pollution
- Cryogenic transfer system cooldown for nuclear rocket engine—used by Chicago Bridge and Iron Co. to design piping systems at most large liquid natural gas import terminals in U.S.
- Nondestructive testing training manuals—used by Mobil to train new employees in maintenance inspection procedures for refineries
- Lubrication handbook—used to solve special lubrication problems—all major oil companies have ordered at least one
- Combustion analysis computer—used by Phillips to generate chemical equilibrium composition tables for all combustion research projects
- Systems safety technology—used to

prepare successful proposal for the Department of Interior for Alaskan Pipeline safety project resulting in $18 million contract award

- Computer program translating guide —used by Shell to convert approximately 500 programs for new computer and by Mobil Oil for same purpose

Education

- Curriculum supplements in mathematics, physics, chemistry, space science, physical science and space biology
- Soldering school for electronic components
- Planetary celestial globe—illustrates interplanetary motion
- Hybrid computer used by medical students
- Phonocardiogram simulator module used by nursing students
- Component degradation analysis techniques course
- Methods for using optical instruments
- Computer program translating guide
- Optical alignment training manual
- Sanitary techniques in food processing
- Hazardous materials safety handbook
- Reading instrument for the blind

Transportation

- Highway grooving for airport runways and highways—greatly reduces accident rate on wet highways
- Apollo guidance computer software used by Los Angeles to control traffic lights in 9-mile square South Bay area
- NASTRAN (NASA Structural Analysis Program)—used by Ford and GM for design analysis and by Pullman Standard in design of new railroad cars
- Saturn 1/1B system development breadboard facility—used by Chrysler to develop new products and for new car & truck testing
- Combustion analysis computer program—used by GM in combustion research on auto and aircraft engines
- Statistical procedures to analyze noise test data from automobile steering systems
- Tires for Apollo 14 Mobile Equipment Transporter—Goodyear uses some rubber compounds in new automobile snow tires that were developed for the Transporter
- Ultrasonic nondestructive testing techniques—used to detect flaws in railroad tracks
- Apollo guidance computer—being tested by Southern Pacific Railroad for control of rail switches and train movement
- Dynamic and static modeling techniques—used by Martin Marietta to develop dynamic model for railroad hopper cars
- Videotape storage and retrieval system—used by Southern Pacific Railroad—one tape stores records from 10 four-drawer file cabinets
- Arc suppression techniques evaluation—used in design of rapid transit switch control products
- Liquid penetration nondestructive testing training manuals—used to train and certify production line inspectors at Beech Aircraft
- Inertial navigation equipment for Apollo and Lunar Module—now installed in many commercial aircraft
- Apollo guidance computer—used by nationwide travel industry in checking credit cards, personal checks, airline tickets, and other non-cash payments
- Friction characteristics of graphite and graphite metal—used by B. F. Goodrich and others in company-sponsored research and development projects related to aircraft brakes and gas turbine engines
- Inflatable/nontippable life raft for recovery of astronauts—now available as survival equipment for pleasure boats and aircraft
- Cooling system for astronaut space suits—adapted for use as galley refrigeration system for commercial aircraft

Manufacturing/Consumer Products/Retailing/Construction

- Battery powered hand tools—commercialized by Black & Decker into line of six cordless power tools for lawns and gardens
- Aluminized mylar developed for ECHO satellite—adapted for use in making blankets, coats, ski parkas, sleeping bags, life raft canopy and various emergency reserve products
- Apollo guidance computer software—used to develop computerized retail sales system used by Montgomery Ward, May Co., Neiman-Marcus, J. C. Penney, Rich's, and many others
- Highly reliable flashlight switch—developed for manned spacecraft, now commercialized
- Composite materials data—used by Babcock & Wilcox Co. to develop products used in business machines and golf club shafts
- Management method—used by Upjohn Co. to save substantial man hours in management of research programs
- Safety yoke for construction workers—developed for Kennedy Space Center workers. Insurance companies now advise use to reduce industrial accidents
- Multiplexer circuit for Saturn rocket —used in most U.S. textile weaving mills and in many foreign countries
- Dry lubricant coating processes—used by over 600 manufacturers, including GE, IBM, RCA, Westinghouse, and ITT
- Intumescent fire retardant coatings—used to coat fuel hoses, fuel tanks, and engine compartments on pleasure boats
- Ultrasonic nondestructive testing techniques—used for quality control inspection in aircraft, steel, railroad, and automotive industries
- Surface finishing method for nickel alloys—used by Westinghouse to finish components for gas turbine electric generators
- Fluidic controls—used to control automatic metalworking lathes
- Lubricant deposition process—used for many products such as film coating and brushes for electric motors used in car air conditioners, vacuum cleaners, etc.
- Specification guidelines for hybrid microcircuits—used by Bell & Howell
- Fracture toughness tests—used by Aluminum Company of America to provide fracture toughness guarantee for high strength alloy products
- Weld strength prediction method—used by Kodak chemical plant to eliminate hazard of rupturing pipes that contain chemicals
- Cryogenic data handbook—used to design low temperature construction projects such as liquid natural

gas storage facilities and refrigeration systems for freezing loose ground in preparation for excavation
- Fiberglass fabric—used for nonflammable clothing and structures
- Geodesic structure design program—used to design commercial geodesic structures
- NASA program evaluation and review technique—used for project scheduling in construction and other industries
- Chlorate candle oxygen supply—technology used to develop portable welding torch
- Quartz crystal oscillator for Apollo central timing equipment—used in clocks and watches; accuracy to within one minute per year
- Combustion analysis computer programs—used by power companies to design firing modifications for power plant fossil-fuel boilers
- Digital color television display—used by electric power companies as part of dispatch computer system to reduce possibilities of major blackouts
- Atlas-Centaur control system—design principles used in control system for high temperature gas-cooled nuclear reactors
- Apollo program quality assurance consulting service for utility companies
- NASA structural analysis program—used for designing nuclear power plant that will float offshore
- Fuel cell technology—NASA needs have spurred private research into fuel cell development
- Fusion welding workmanship standards—used to develop weld methods for the Foster Joseph Sayers Dam project in Pennsylvania
- Heat shield coating for reentry vehicles—NASA requirements have encouraged private development of heat resistant coatings for construction materials
- Instrumentation electronics for Saturn rocket—used to design a ground fault interrupter that will fit inside a standard home circuit breaker
- Computer program translating guide—used to design foundations for building, such as the Sears Building in Chicago
- Deployable lattice column—used for stage light supports for traveling shows, portable power poles, etc.
- Linear shaped explosive charge—used in demolition industry for controlled removal of buildings and bridges
- Mass flowmeters for low gas flow—used extensively by manufacturers in U.S., Europe and Japan for assorted applications
- Technique for reducing noise in radio amplifiers—used by GTE and Sylvania in high sensitivity-low noise receivers
- Apollo Program Management Techniques—used by Rockwell International in production of truck and bus components
- Spun metal fibers for web filters—developed by Hydraulic Research and Manufacturing Co. for Apollo, now commercially available for many different applications
- Heat pipe technology—Air-O-Space heater by Isothermics, Inc., recovers waste heat from furnace flue gas, increases heat efficiency 8 to 10%
- Rogallo airfoil design—used as a basis for design of hang gliders
- Anti-fog compound—used for fire fighters face shields, air masks, ski goggles, eyeglasses, etc.

Food Production and Processing

- Weather satellite imagery—used in preparing daily fishery advisory charts for commercial fishermen in eastern Pacific
- Compressed/freeze-dried food—used as compact emergency food rations
- Fracture toughness tests—used by Deere to select steel for farm tractors and implements
- Precipitation-hardened steel alloy for Apollo Command Module—used in fabricating ram-jet wind machine for frost protection of orchards
- Clean room technology—developed and used by Pillsbury and to train federal food inspectors
- Contamination control handbook—used by U.S. Department of Agriculture (USDA) Research Center in Louisiana to train employees
- Microbiological handbook—used by Kraft Co. as training manual for sanitary techniques in food processing and by USDA to develop improved milk processing procedures
- Eurtectic salts for low temperature batteries—used to develop product that shows whether frozen foods have defrosted during transportation or storage

Government and Law Enforcement

- Saturn rocket systems development breadboard facility—used to design memory system for new Post Office automated parcel sorting equipment
- Slidell computer complex—used by National Weather Service to forecast flow of rivers in five-state area
- Apollo management control room—used to design management control rooms for other government projects
- Space simulation chamber—used to restore water-damaged records with heating/freeze drying process
- Fireman's breather apparatus—features reduced weight, increased duration, and simplified harness, also helmet/mask assembly and air depletion warning device are improved
- Flammability tests of home furnishings—used by USDA to design better fire tests
- Scientific and technical information management system—primary storing and retrieving system for the National Criminal Justice Reference Service
- Videotape storage and retrieval system—used by law enforcement agencies, including the Royal Canadian Mounted Police
- Systems analysis and computer modeling—used to develop citywide emergency command and control communications system
- High intensity arc radiation source—adapted for use as a portable high intensity spotlight for use by police and fire departments, it can operate from automobile cigarette lighter and is brighter than headlights of 50 automobiles

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Note: Detailed information about the above aerospace technology transfers may be obtained from:

Code KT
Technology Utilization Office
NASA Headquarters
Washington, DC 20546

Careers In Aerospace and Related Fields
Trade, Professional and Educational Sources

Aerospace and Aviation

A Giant Leap for Womankind Too, National Geographic Society, 17th and M Streets, N.W., Washington D.C. 20036. (1973) 10¢

Airport Management—A Profession, American Association of Airport Executives, 2029 K Street, N.W., Washington, D.C. 20006. (1971)

Airworthy . . . A Career as an A&P Mechanic, General Aviation Manufacturers Association, Suite 1200-A, 1025 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

ALPA Occupational Guides, Air Line Pilots Association, 1329 E Street, N.W., Washington, D.C. 20004. (1971)

Aviation Education Materials, General Aviation Manufacturers Association, Suite 1200-A, 1205 Connecticut Avenue, N.W., Washington, D.C. 20036. (1972)

Careers in Aerospace, American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, NY 10019. (1971)

Careers in Aerospace Medicine and Life Sciences, The Aerospace Medical Association, Washington National Airport, Washington, D.C. 20001. (1970)

Flight Engineer—Fact Sheet, Flight Engineers' International Association, 905 Sixteenth Street, N.W., Washington, D.C. 20006. (1971)

Going Up! . . . A Career as a Professional Pilot, General Aviation Manufacturers Association, Suite 1200-A, 1025 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

Help-Mate . . . A Career Using Personal Flying, General Aviation Manufacturers, Suite 1200-A, 1025 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

Mr. Aviation . . . A Career as a Fixed Base Operator, General Aviation Manufacturers Association, Suite 1200-A, 1025 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

Sky-School . . . A Career as a Flight Instructor, General Aviation Manufacturers Association, Suite 1200-A, 1025 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

The People of the Airlines, Air Transport Association of America, 1709 New York Avenue, N.W., Washington, D.C. 20006. (1973)

The World of Agricultural Aviation, National Agricultural Aviation Association, Suite 808, 1101 Seventeenth Street, N.W., Washington, D.C. 20036. (1972)

Transport Career Opportunities, National Defense Transportation Association, 1612 K Street, N.W., Washington, D.C. 20006. (1972) $5

Engineering

Biomedical Engineering Education Summary Directory 1971, Biomedical Engineering Directory, AIBS/BIAC, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016. (1971)

Career Guidance Reprints, Society of Women Engineers, 345 East 47th Street, New York, NY 10017. (Dates vary)

Careers in Photographic Science and Engineering, Society of Photographic Scientists and Engineers, 1330 Massachusetts Avenue, N.W., Washington, D.C. 20005. (1973)

Chemical & Engineering News: Career Opportunities for Chemists, Employment Outlook '73, American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036. Represent 10/2/72. $1. (1972)

Chemical Engineering and You . . ., American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017. (1970)

Consulting Engineering . . . A Career With a Future, Consulting Engineers Council of the USA, 1155 15th Street, N.W., Washington, D.C. 20005. (1971)

Engineering: A Career of Dedication and Responsibility, National Society of Professional Engineers, 2029 K Street, N.W., Washington, D.C. 20006. (1974)

Engineering Guidance and Counseling, American Society for Engineering Education, One Dupont Circle, Suite 400, Washington, D.C. 20036. (1972) $2.50

Engineering Technician, American Society for Engineering Education, One Dupont Circle, Suite 400, Washington, D.C. 20036. (1971) 50¢

Engineers Council for Professional Development, 345 East 47th Street, New York, NY 10017. The following guidance materials are available from ECPD. Single copies (except where noted) will be sent to students and counselors:

After High School—What? (EC-13)1969
Do I Have Engineering Aptitude (EC-14) 1969
Guidance Counselor Kit (EC-19) 1973 $4
Engineering: Creating A Better World (EC-62) 1970
New Careers in Engineering Technology (EC-63) 1970
Make Your Career Choice Engineering (EC-68) 1974
The Engineering Team (EC-69) 1974
Engineering Career Series (EC-70) 1973
Minorities in Engineering (EC-71) 1974
Accredited Curricula Leading to Degrees in Engineering (EC-20) 1972
List of Accredited Curricula Leading to Degrees in Engineering Technology (EC-21) 1972

Industrial Engineering, The Professional With a Future, The American Institute of Industrial Engineers, Inc., 25 Technology Park, Atlanta, GA 30071. (1974)

Manufacturing Engineering, A Rewarding Career, The Society of Manufacturing Engineering Engineers, 20501 Ford Road, Dearborn, MI 48128. (1974)

Mechanical Engineering, The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10006. (1973)

The Metallurgical Engineering Technician, American Society for Metals, Metals Park, OH 44073. (1972)

Road to Graduate School in Engineering, American Society for Engineering Education, One Dupont Circle, Suite 400, Washington, D.C. 20036. Revised periodically. 50¢

Science and Engineering Careers—A Bibliography, 7th Edition, Scientific Manpower Commission, American Academy for the Advancement of Science, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036. (1974) $2

Team 'work', American Institute of Industrial Engineers, Inc., United Engineering Center, 345 East 47th Street, New York, NY 10017. (1972)

The Certification of Engineering Technicians, Institute for the Certification of Engineering Technicians, 2029 K Street, N.W., Washington, D.C. 20006. (1974)

The Engineering Technician, American Society for Engineering Education, Suite 400, One Dupont Circle, Washington, D.C. 20036. (1970)

The Future Belongs to the Chemical Engineer, American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017. (1973)

The Jets Program, The Junior Engineering Technical Society, United Engineering Center, 345 East 47th Street, New York, NY 10017.

Women in Engineering Careers, Society of Women Engineers, United Engineering Center, Room 305, 345 East 47th Street, New York, NY 10017. (1970)

Your Challenge in Electrical Engineering, Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017. (1972)

Industry

An Introduction to Die Casting, The Society of Die Casting Engineers, 14530 West 8 Mile Road, Detroit, MI 48237. (1970)

Careers in Metallurgy, Materials Science, and Metallurgical Engineering, The Metallurgical Society of AIME, 345 East 47th Street, New York, NY 10017. (1974)

Careers in Quality, American Society for Quality Control, 161 West Wisconsin Avenue, Milwaukee, WI 53203. (1974)

Directory of Colleges and Universities Offering Photography Instruction, Professional Photographers of America, 1090 Executive Way, Oak Leaf Commons, Des Plaines, IL 60018. (1974)

Directory of Transportation Education, National Defense Transportation Association, 1612 K Street, N.W., Washington, D.C. 20006. (1972)

Education for Technical Writers, Society for Technical Communication, Suite 421, 1010 Vermont Avenue, N.W., Washington, D.C. 20005. (1970)

Focus on the Future, Professional Photographers of America, 1090 Executive Way, Oak Leaf Commons, Des Plaines, IL 60018. (1972)

Is Technical Writing Your Career?, Society for Technical Communication, Suite 421, 1010 Vermont Avenue, N.W., Washington, D.C. 20005. (1971)

Machine Tools/American Muscles, National Machine Tool Builders, 2139 Wisconsin Avenue, N.W., Washington, D.C. 20007. (1969)

Measurement and Control Industry, Scientific Apparatus Makers Association, 370 Lexington Avenue, New York, NY 10017. (1972)

Planning a Career in Electronics, Electronic Industries Association, 2001 "I" Street, N.W., Washington, D.C. 20006. (1971)

Your Introduction to Photogrammetry, The American Society of Photogrammerty, 105 N. Virginia Avenue, Falls Church, VA 20046. (1973)

Your Career in Fluid Power, The Fluid Power Society (FPS), 432 East Kilbourn Avenue, Milwaukee, WI 53201. (1973)

This bibliography was prepared by the National Career Information Center of the American Personnel and Guidance Association, 1607 New Hampshire Avenue, N.W., Washington, D.C. 20009. (1976)

Science

A Bright Future For You as a Chemical Technician, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009. (1972)

A Career in Astronomy, American Astronomical Society, 211 Fitz Randolph Road, Princeton, NJ 08540. (1972)

A Career in Ecology, Ecological Society of America, Department of Botany, University of North Carolina, Chapel Hill, NC 27514. (1972)

A Career in Metallurgy Will Extend Your Reach, Career Development Office, American Society for Metals, Metals Park, OH 44073. (1970)

Accredited Curricula in Chemical Engineering, American Institute of Chemical Engineers, 345 East 47th Street, New York, NY 10017. (1973)

Biological Photography—A Challenging Profession, Biological Photographic Association, Box 1057, Rochester, MN 55901. (1973)

Agricultural Careers in Science, Business and Education, Ak-Sar-Ben-Ag Youth Foundation, 110-C Information, College of Agriculture, University of Nebraska, Lincoln, NE 68053. (1974) 25¢

Careers in Biology, American Institute of Biological Sciences, 3900 Wisconsin Avenue, N.W., Washington, D.C. 20016. (1971)

Careers Ahead in the Chemical Industry, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009. (1971)

Careers in Exploration Geophysics, Society of Exploration Geophysics, Box 3098, Tulsa, OK 74101. (1971)

Careers in Statistics, Committee of Presidents of Statistical Societies, c/o American Statistical Association, 806 15th Street, N.W., Washington, D.C. 20005. (1974)

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Chemistry and Your Career, American Chemical Society, 1155-16th Street, N.W., Washington, D.C. 20036. (1970)

Curricula in the Atmospheric Sciences, The American Meteorological Society, 45 Beacon Street, Boston, MA 02108. Revised periodically. ($4)

Directory of Geoscience Departments, American Geological Institute, 2001 M Street, N.W., Washington, D.C. 20037. Revised periodically. ($4)

Documentary Resources for Environment/Ecology Education (E/EE)—A Bibliography, Institute of Environmental Sciences, 940 East Northwest Highway, Mt. Prospect, IL 60056. $1.50. (1972)

Environmental Health Programs, Graduate Level, National Environmental Health Association, 1600 Pennsylvania Street, Denver, CO 80203. (1971)

Environmental Health Technician, National Environmental Health Association, 1600 Pennsylvania Street, Denver, CO 80203. (1971)

Environmental Programs in Two Year Colleges, National Environmental Health Association, 1600 Pennsylvania Street, Denver, CO 80203. (1971)

Geology—Science and Profession, American Geological Institute, 2201 M Street, N.W., Washington, D.C. 20037. 35¢. (1970)

Geophysics, The Earth in Space, American Geophysical Union, 2100 Pennsylvania Avenue, N.W., Washington, D.C. 20037. (1972)

Guidebook to Departments in the Mathematical Sciences, The Mathematical Association of America, 1225 Connecticut Avenue, N.W., Washington, D.C. 20036. Revised Periodically. ($1)

How About a Career in Mathematics, The Mathematical Association of America, 1225 Connecticut Avenue, N.W., Washington, D.C. 20036. (1972)

Keys to Careers in Science and Technology, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20009. (1973) $1

Microbiology in Your Future, American Society for Microbiology, 1913 "I" Street, N.W., Washington, D.C. 20006. (1974)

Oceanography Information Kit, National Oceanography Association, 1900 L Street, N.W., Washington, D.C. 20036. (1972) ($2)

Physics as a Career, American Institute of Physics, 335 East 45th Street, New York, NY 10017. (1970)

Post-Secondary Curriculums in Environmental Technology, National Sanitation Foundation, Box 1468, Ann Arbor, MI 48106. (1971)

Preparing for a Career in Oceanography, Scripps Information of Oceanography, P.O. Box 109, La Jolla, CA 92037.

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The Challenge of Meteorology, The American Meteorological Society, 45 Beacon Street, Boston, MA 02108. (1971)

The Environmentalist, National Environmental Health Association, 1600 Pennsylvania Street, Denver, CO 80203. (1973)

The Sphere of the Geological Scientist, American Geological Institute, 2001 M Street, N.W., Washington, D.C.20037. (1970) (404)

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You'll Need Math, The Mathematical Association of America, 1225 Connecticut Avenue, N.W., Washington, D.C. 20036. (1971)

Additional Sources of Information

Engineering Manpower Commission, 345 East 47th Street, New York, NY 10017.

National Aerospace Education Association, Shoreham Building, 806 15th Street, N.W., Washington, D.C. 20005

Federation of American Supporting Science and Technology, 1785 Massachusetts Avenue, N.W., Washington, D.C. 20036.

National Aeronautic Association, Room 610, 806 15th Street, N.W., Washington, D.C. 20005.

Aerospace Youth Council, 1785 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Aerospace Education Foundation, 1750 Pennsylvania Avenue, N.W., Washington, D.C. 20006.

Aviation Technician Education Council, P.O. Box 51133, Tulsa, OK 74151.

Aviation Distributors and Manufacturers Association, 1900 Arch Street, Philadelphia, PA 19103.

Government Sources

Occupational Outlook Reprint Services, U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C. 20402.

Aircraft, Missile and Spacecraft, #123, 25¢.
Civil Aviation, #138, 35¢.
Engineers, #63, 30¢.
Environmental Scientists, #64, 30¢.
Physical Scientists, #67, 30¢.
Technicians, #68, 30¢.

Federal Careers for Technicians in Engineering and Physical Science, U.S. Civil Service Commission, 1900 E Street, N.W., Washington, D.C. 20415. (1972)

Career Materials, Department of Transportation, Federal Aviation Administration, Office of Information Services, Public Information Center, 800 Independence Avenue, S.W., Washington, D.C. 20591.

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25 Technical Careers You Can Learn in Two Years or Less, Career, U.S. Department of HEW, Office of Education, Washington, D.C. 20202.

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Career Education in the Environment—A Handbook, Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. 1780-0892. 1972. (S3)

Publishers

Alumnae Advisory Center, 541 Madison Avenue, New York, NY 10022.

B'nai B'rith Career and Counseling Services, 1640 Rhode Island Avenue, N.W., Washington, D.C. 20036.

Careers, Inc., Box 135 Largo, FL 33540.

Chronicle Guidance Publications, Inc., Moravia, NY 13118.

Dodd, Mead, and Company, 79 Madison Avenue, New York, NY 10016.

J. G. Ferguson Publishing Company, 6 North Michigan Avenue, Chicago, IL 60602.

Julian Messner, 1 West 39th Street, New York, NY 10018.

William Morrow & Company/Lothrop Lee and Shepard, 105 Madison Avenue, New York, NY 10016.

Richards Rosen Press, Inc., 29 East 21st Street, New York, NY 10016.

Science Research Associates, Inc., 259 East Erie Street, Chicago, IL 60611.

Vocational Guidance Manuals, 620 South Fifth Street, Louisville, KY 40202.

Business and Industrial Sources

Can I Be a Technician? Let's Find Out, Public Relations Staff, General Motors Corporation, Detroit, MI 48202.

Can I Be an Engineer? Public Relations Staff, General Motors Corporation, Detroit, MI 48202. (1972)

Can I Be a Craftsman?, Public Relations Staff, General Motors Corporation, Detroit, MI 48202.

What's it Like to be an Engineer?, Educational Relations, General Electric Company, Ossining, NY 10562. (1972)

What's it Like to be a Technician?, Educational Relations, General Electric Company, Ossining, NY 10562. (1972)

Aerospace Education, Aero Products Research Inc., 11201 Hindry Avenue, Los Angeles, CA 90045.

Piper Air Science Education and College in the Clouds, Aero Products Research, Inc., 11201 Hindry Avenue, Los Angeles, CA 90045.

Sperry's There and It's a Cold Cruel World, Sperry Flight Systems, P.O. Box 2111, Phoenix, AZ 85036.

Your Future at Grumman, Grumman Aerospace Corporation, Bethpage, NY 11714.

Your Career in the World of Bendix, Bendix Corporation, Bendix Center, Southfield, MI 48076.

It's Your Turn, Fairchild Industries, 20301 Century Blvd., Germantown, MD 20767.

Tech-Notes, Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, NJ 07424.

Blueprint for Future, Vought Systems Division—LTV Aerospace Corporation, P.O. Box 5907, Dallas, TX.

Careers in Aerospace, The Boeing Company, P.O. Box 37073 M/S 11-48, Seattle, WA 98124.

Aviation Education Materials, Beech Aircraft Corporation, Education Department, Wichita, KS 67201.

Aviation Education Programs, Cessna Aircraft Company, P.O. Box 1521, Wichita, KS 67201.

Employment Fact Sheet: NASA

General Information

1. *Types of Vacancies*
Generally, there is a continuing need for typists and stenographers in addition to entry-level (GS-5, 7, and 9) engineers, physical scientists, and mathematicians. Although NASA has some positions primarily supporting various management and administrative programs, vacancies are relatively limited in these areas.

2. *Where Vacancies Occur*
NASA employment opportunities at NASA Headquarters in Washington,

D.C. and at its field installations throughout the country are limited. Numbers and types of personnel needed fluctuate. There are generally more positions to be filled at NASA field installations than at NASA Headquarters particularly for entry-level science and engineering positions. Opportunities for overseas employment are extremely rare.

3. *Qualifications*
Specific qualifications vary with the many occupational areas. To be eligible for professional positions related to engineering, physical science, mathematics, and the life sciences, an applicant must have at least a bachelor's degree in an appropriate field from an accredited college or university.

4. *Citizenship*
Employment in the Federal service of the United States is restricted by Presidential Executive Order to citizens, except in those cases where the non-citizen possesses unusually valuable technical or scientific knowledge or experience not obtainable from a U.S. citizen.

5. *Competitive Service*
Positions in NASA are in the competitive civil service. For all such positions applicants must have competitive civil service status or be within reach on an appropriate Civil Service register. Further information may be obtained from your local Federal Job Information Center.

6. *Summer Employment*
Throughout NASA there are limited numbers of short-term summer positions in many areas of work. Clerical jobs such as clerk-typist, clerk-stenographer, and clerk-administrative aid in grades GS-1 through GS-4 do not require a degree, and applications for the required written exam must be sent directly to the Civil Service Commission, generally before the beginning of the calendar year. Subprofessional, technical or nonclerical jobs in grades GS-1 through GS-4 require college study or experience in specific occupational fields, and jobs in specialized positions in grades GS-5 and above require at least a bachelor's degree. Additional information on summer jobs may be obtained from your local Federal Job Information Center.

7. *Part-Time Employment*
Part-time positions are limited in number and the opportunity for such employment varies from installation to installation.

8. *How and Where to Apply*
To notify them of your interest in employment, a completed Personal Qualifications Statement (Standard Form 171) should be sent directly to the Personnel Office of the NASA installation at which you desire employment. If more than one location is acceptable, send a separate application to each. Standard Form 171's may be obtained at any U.S. Post Office or Job Information Center. Applicants who are not current or former Federal employees eligible for transfer or reinstatement must establish basic eligibility for employment consideration through competitive examination.

9. *Detailed Information*
We do not publish a list of vacancies. Specific information concerning salaries, vacancies, conditions of employment, etc., should be directed to the Personnel Office at the installation at which employment is desired.

10. *All qualified applicants* will receive consideration for employment without regard to race, color, age, religion, sex or national origin.

"That's One Small Step for a Man, One Giant Leap for Mankind"

First words of Apollo 11 Commander Neil A. Armstrong when he became the first human to step on the surface of the Moon—July 20, 1969.

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